DRINKING WATER SYSTEM OPTIMIZATION ANALYSIS

(HAL Project No.: 260.40.100)

FINAL REPORT

August 2014

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ENGINEERS

SPRINGVILLE CITY

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August 2014

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ACKNOWLEDGMENTS

Successful completion of this study was made possible by the cooperation and assistance of many individuals at Springville City as shown below. We sincerely appreciate the cooperation and assistance provided by these individuals.

SPRINGVILLE CITY

Wilford Clyde, Mayor
Mark Packard, Councilman
Chris Creer, Councilman
Ben Jolley, Councilman
Rick Child, Councilman
Dean Olsen, Councilman
Brad Stapley, Public Works Director
Shawn Barker, Water Department Superintendent
Jeff Anderson, City Engineer
Noah Gordon, Staff Engineer

CHAPTER I

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this water system optimization analysis is to assess the efficiency of the drinking water distribution system and to provide operational recommendations to Springville City. The following resources were used during this study: Springville's previous drinking water master plan, a computer hydraulic model of the existing drinking water distribution network, GIS data of the distribution network, recent water billing data, electricity billing data, water quality data, and input from Springville City personnel.

This analysis is a study of the operation of the City's water system and includes the following: system performance, water transmission, well operation, storage utilization, pump station operation, control valve settings, and water quality (water age, disinfection byproduct, and chlorine residual). As part of this analysis, the City's hydraulic model was updated and enhanced in order to improve the dynamic extended period operation of the model. An extended period water model is a valuable tool to understand in detail how a water system is performing and how to best optimize the efficiency of the water system.

From this study of the water system's operation and efficiency, observations and recommendations have been prepared. It is anticipated that the City will use the extended period model and information developed in this analysis to make educated decisions to operate the system more efficiently and plan for projects that make the system more sustainable. The information developed in this analysis will help the City extend the life of existing facilities by improving system performance, reducing the amount of energy used, and helping the City exceed customer expectations at the lowest possible cost.

The observations and recommendations of this study are limited by the accuracy of the assumptions used in preparing the study. It is expected that the City will make ongoing updates to the extended period hydraulic model and use the model as a tool to continue to improve the efficiency of the drinking water system. It is not the intent of the analysis to have the City match exactly all the settings from the study model. Rather, the purpose of the analysis is to provide ideas and tools for City personnel to start the ongoing process of implementing system optimization measures that will provide sustainable system performance, cost savings, and water quality improvements.

BACKGROUND

Springville City is located in Utah County southeast of Provo. Springville City has been experiencing rapid growth. Between 2000 and 2010, the population of Springville increased by 44.3%. As of the 2010 census, the City had a population of 29,466. The water system currently includes approximately 8,200 connections. Water is supplied by four springs and five active wells.

WATER SYSTEM OPTIMIZATION ANALYSIS APPROACH

A water system consists of water sources, storage facilities, pumping facilities, and a distribution system. Water system components and operation should be designed and coordinated so they operate efficiently under a range of water demand requirements. The water system must be capable of responding to daily and seasonal variations in demand. The approach taken in this optimization analysis was to first prepare a realistic extended simulation period model for existing conditions and then analyze each control valve, well, pump station, and storage facility for operational performance. The model was then used to develop observations and recommendations to increase energy efficiency, water quality, and system performance. The key to water system optimization is to find a balance. It is important to ensure system performance and water quality do not suffer because of too much focus on energy efficiency and vice versa.

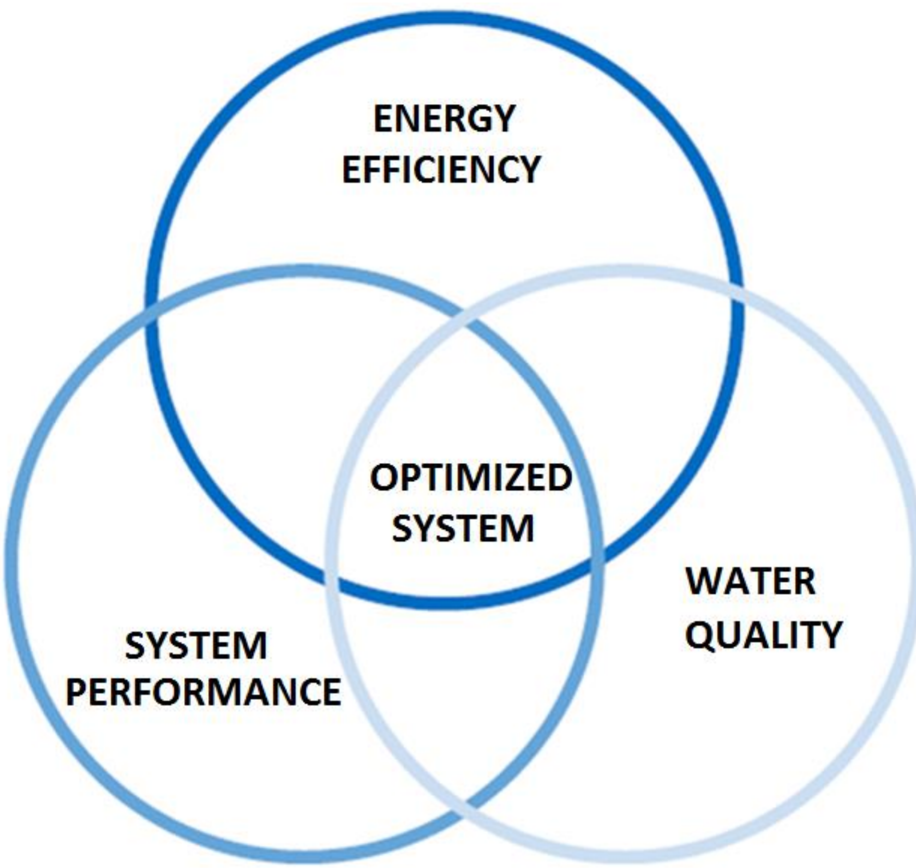

Figure I-1 An optimized water system is a balance between system performance, energy efficiency and water quality.

CHAPTER II

EXTENDED PERIOD WATER SYSTEM MODEL

In 2010 Hansen, Allen & Luce (HAL) updated the hydraulic model of the City's drinking water distribution network. Previously, the model had been operated strictly as a steady state model. A steady-state hydraulic model represents a snapshot in time used to determine system behavior under static conditions. It is used to simulate worst case pressure and flow conditions assuming settings that do not change. During the course of the 2010 model update, many elements necessary for running extended period simulations were added to the model. An extended period model describes system behavior over a period of time. Within an extended period model, tanks fill and drain as pumps turn on and off. Modeled demands are also varied in order to match trends observed within the distribution system. Pressures and flow rates within the model change in response to the demands and model conditions. An extended period model can also simulate system controls, water quality, and energy consumption. Building upon the 2010 model update, the current study completed the transition of the Springville model from a steady state model to an extended period model. The location and attributes of the tanks, wells, springs, and booster pump stations were verified and accounted for in the completed model.

After assembling the elements of the hydraulic model, it was necessary to define the system demands. Water demand within the system was assigned using billing data, water source data, and by developing a diurnal curve. Monthly billing data were provided to HAL by City personnel. The billing data included the monthly water demand from October 2011 to September 2012 for each of the City's water customers along with the corresponding address. The demand was distributed within the model through the use of geocoding. Geocoding is a process whereby street addresses are converted into geographic coordinates. After converting the addresses to geographic coordinates, the associated demands were distributed to the model node closest to the demand.

After distributing the demand, the volume of the demand was adjusted based on source water data. Billing data were multiplied by a factor so that the total average volume of demand within the hydraulic model equaled the production of the City's sources. Not all of the water that enters the drinking water is metered on the way out. Water leaks, fire hydrant use, and other unmetered water use are accounted for through the use of this multiplication factor. Source water volume was determined from a combination of data sources, including production data reported to the Utah Division of Water Rights (DWR), SCADA data, and conversations with City personnel. Table II-1 is a summary of the demand volume by pressure zone.

In addition, to defining nodal demands, it was also necessary to develop a diurnal curve. A diurnal curve describes the demand variation within a drinking water system during the course of one day. The diurnal curve for Springville was developed using the aforementioned SCADA and production data and is shown in Figure II-1. The curve shown in Figure II-1 is dimensionless and is obtained by dividing the instantaneous flow by the peak day average flow. The primary peak occurs just before 6:00 AM with a peaking factor of 1.55. Smaller, secondary peaks occur in the latter hours of the day between 9:00 PM and 11:00 PM.

TABLE II-1
JUNE 2012 AVERAGE DEMAND

ZONE	DEMAND (GPM)
Bartholomew	25
Upper Spring Creek	67
Jurg	91
Rotary	91
Rotary PRV	530
Crandall	136
Klauck	238
Hobble Creek	2,886
Lower Spring Creek	4,484
Nestle	533
West Fields	3,379
Total	12,460

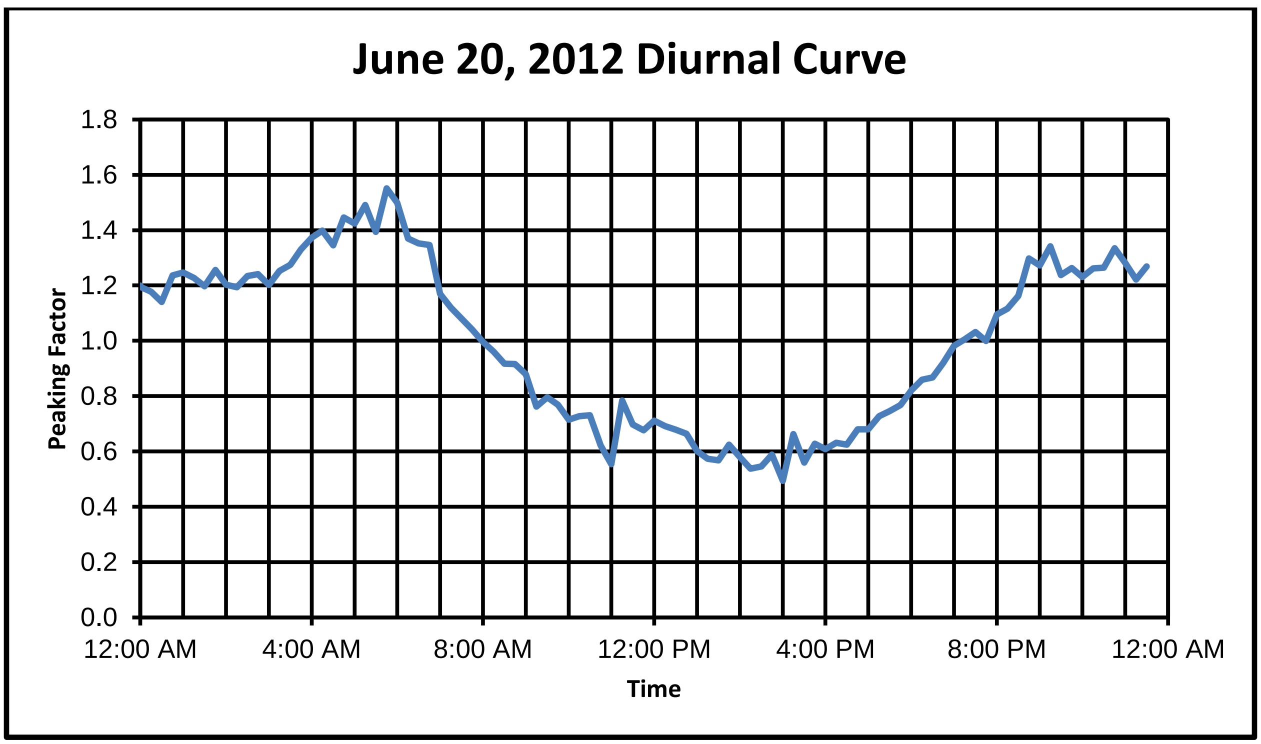

FIGURE II-1 Summer water use diurnal curve.

The steady-state model was developed into an extended period model by adding control settings based on a review of SCADA data and conversations with City personnel. Each pump turn-on and turn-off set point controlled by tank levels was entered into the model. In addition to the controls, pump curves were entered for each pump in the system. Where available, manufacturer's pump curves were entered for the pumps. Otherwise, curves were based on engineering judgment using the available data and known pumping characteristics.

Extended period modeling was completed using EPANET 2.0. EPANET 2.0 is hydraulic modeling software developed by the Environmental Protection Agency. Most commercially available hydraulic water models use EPANET as the computational engine, including the commercial software that the City owns. HAL prefers to use EPANET 2.0 because of its ease of use in performing the type of analyses required for the system optimization analysis. Installation files for EPANET 2.0 along with files for each of the scenarios developed during the course of this optimization analysis are contained on a disk in Appendix A.

MODEL CALIBRATION

A water system computer model should be calibrated before relying on it to accurately simulate the performance of the distribution system. Calibration is a comparison of the computer results, field tests, and actual system performance as recorded by the SCADA system. When the computer model does not match the field tests within an acceptable level of accuracy, the computer model is adjusted to match field conditions or field investigations are performed to ensure facility conditions are accurately simulated. The following data were provided by the City for use in calibrating the extended period model: pressure readings from field measurements, pump flows from SCADA, and reservoir levels from SCADA. In order to perform the extended period calibration, a 24-hour time period was selected within the available SCADA data. The model was then used to replicate the details shown in the SCADA data. In addition to comparing flows and pressures, pumping on and off times, tank levels, and other system control data were matched. A higher level of calibration is usually achieved with an extended period time model because there are fewer unknowns than in a static model and errors are amplified over time. Several errors in the model were identified during the extended period model calibration effort in which City personnel were able to determine how the error should be fixed to match model conditions to the actual system. The resulting calibrated model performs similarly to the existing water system (see Appendix B for model versus measured data figures).

CHAPTER III

SYSTEM OPTIMIZATION ANALYSIS

After calibration, the extended period water model was used to identify water system operation inefficiencies and possible locations for system improvements. Two primary signs in locating system inefficiencies are localized high water velocities and large diurnal pressure variations. Additional criteria include storage utilization, excessive PRV flows, and overuse of booster pumps. In general, the calibrated model shows that the water distribution network is operating with reasonable flow velocities and diurnal pressure variations during peak day demands. Although the overall level of service for the Springville water system is good, areas of potential improvement were identified within the system.

This chapter includes a discussion of each system facility and identifies recommended efficiency and optimization improvements (see Figure III-1 for a map of the existing water system facilities). Changes are recommended based on several overall optimization goals 1) Increase efficiency of electricity usage 2) Maximize the use of equalization storage, and 3) Maintain normal pressures throughout the system at all customer connections.

Power in Springville City is provided by the City owned power utility, Springville Power. All of the City's pumps utilize the same rate structure and there are no additional options for plans that emphasize cost savings through off peak use or other time-of-day usage patterns. Table III-1 presents the energy cost and flow capacity for each of the Springville sources. The energy cost and flow capacity of each pump station are shown in Table III-2.

TABLE III-1
EXISTING ENERGY COST AND CAPACITY FOR EACH SOURCE

NAME	ZONE	EXISTING ENERGY COST (PER AC-FT)	CAPACITY (GPM)
Bartholomew Springs	Bartholomew	$0	2,700
Spring Creek Springs	Upper Spring Creek	$0	2,700
900 South Well	Hobble Creek	$45	3,200
1000 South Well	Hobble Creek	$72	550
Burt Springs	Hobble Creek	$64	1,200
Canyon Road Well	Hobble Creek	$55	2,000
Evergreen Well	Hobble Creek	NOT USED	600
200 North Well	Lower Spring Creek	$56	3,200
400 S Well	Lower Spring Creek	$39	3,000
Konold Springs	Lower Spring Creek	$0	200

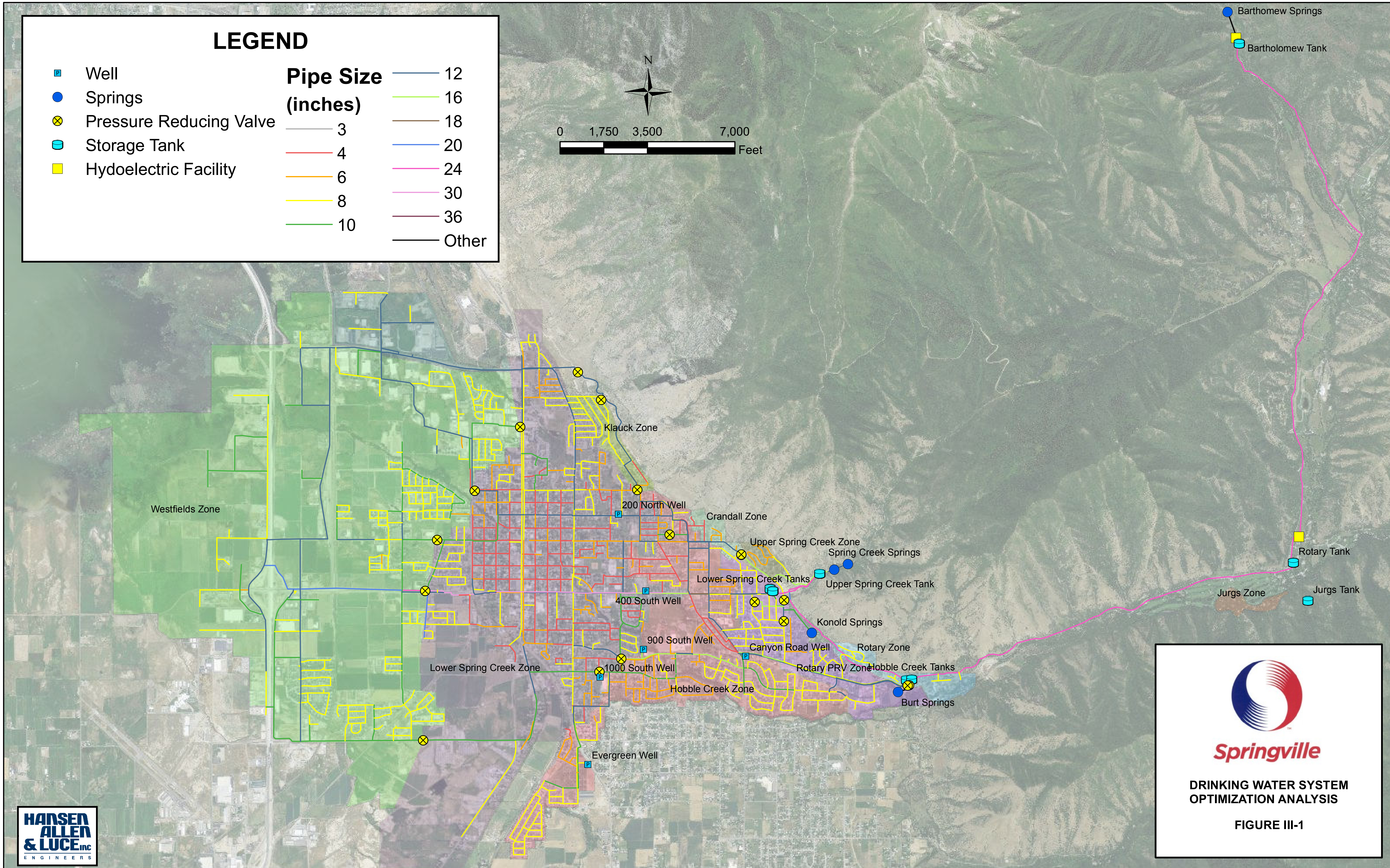
LEGEND
Well
Springs
Pressure Reducing Valve
Storage Tank
Hydoelectric Facility
Pipe Size (inches)
3
4
6
8
10
12
16
18
20
24
30
36
Other
N
0
1,750
3,500
7,000
Feet
Barthomew Springs
Bartholomew Tank
Klauck Zone
200 North Well
Crandall Zone
Westfields Zone
Upper Spring Creek Zone
Spring Creek Springs
Lower Spring Creek Tanks
Upper Spring Creek Tank
Rotary Tank
Jurgs Zone
Jurgs Tank
400 South Well
Konold Springs
900 South Well
Canyon Road Well
Rotary Zone
Lower Spring Creek Zone
1000 South Well
Rotary PRV Zone
Hobble Creek Tanks
Hobble Creek Zone
Burt Springs
Evergreen Well
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FIGURE III-1

TABLE III-2
EXISTING ENERGY COST AND CAPACITY FOR EACH PUMP STATION

NAME	EXISTING ENERGY COST (PER AC-FT)	CAPACITY (GPM)
Jurg Pump Station	$135	91[1]
Spring Creek Pump Station	$90	3,300

1. The pump station includes two pumps and it is believed that 91 gpm represents the capacity of the smaller of the pumps. The capacity of the larger pump is not known.

One potential option for future cost savings is to add plans that favor off peak usage. The possibility of adding time-of-day rate schedules should be discussed with Springville Power. Such plans could provide the City water utility a valuable opportunity for cost savings while simultaneously reducing infrastructure expansion costs for the power utility.

The optimization recommendations have been organized according to pressure zone, starting from the highest pressure zone in elevation (Bartholomew) down to the lowest (West Fields). Recommended settings are for year-round operation unless otherwise specified. As demand diminishes at the end of the irrigation season, it is generally recommended that higher cost sources be shut down first and then started up last in the spring. However, a few Springville sources are especially useful for maintaining pressures within specific areas of the distribution network. At times, it may be necessary to use these pressure maintaining sources to the exclusion of other sources with lower energy costs. Sources which provide particular benefits are identified within the following narrative along with the benefit provided. As an aid in performing the optimization analysis, a mass balance of the system wide water production and demand was prepared and is included in Appendix C.

BARTHOLOMEW

Bartholomew Zone is located in Bartholomew Canyon, northeast of Springville City. As shown in Table II-1, there are relatively few connections in the Bartholomew Zone. All of the water in Bartholomew Zone is provided by Bartholomew Springs which flows into Bartholomew Tank. Bartholomew Tank is connected to Rotary Tank via a 24-inch transmission line. A hydroelectric facility separates Bartholomew Zone from Rotary Zone. The primary recommendation for the Bartholomew Zone is that flow from Bartholomew Springs should be maximized. Water from Bartholomew Springs has no pumping cost while providing revenue as a result of the hydro facility.

UPPER SPRING CREEK

The Upper Spring Creek Zone is located just northwest of the mouth of Spring Creek Canyon. Demand within the zone is supplied by Spring Creek Springs which flows into the Upper Spring Creek Tank. The spring collection and Upper Spring Creek Tank are at a sufficiently high elevation such that flow to the Upper Spring Creek Zone is provided by gravity. As a result, the springs have no pumping cost and, along with Bartholomew Springs, are some of the City's most economical sources. Because the water has no cost associated with production, Spring Creek Springs should be utilized to the extent possible. Water from the Upper Spring Creek Zone can flow into the Crandall Zone via a PRV or down to the Lower Spring Creek Tank by means of an overflow in the Upper Spring Creek Tank. During periods of low spring flow, water can also be pumped from the Lower Spring Creek Tanks to the Upper Tank by using a pump station near the Lower Tanks. Due to the added cost of operating the pump station, it should only be utilized if the Upper Spring Creek Source is providing insufficient flows.

JURG

Jurg Zone is a small zone, just southeast of Rotary Tank, which receives water through a booster station connected to the main transmission line coming south out of Rotary Tank. The booster station includes two pumps, a larger pump for emergency flows and a smaller pump for every-day use. Electrical billing records for the Jurg booster station indicate that the City currently spends just under $19,000 per year for power to operate the Jurg pump station. Direct flow data for the pump station is limited; however, billing data for the homes served by the pump station suggest that the average flow rate for the pump station is about 91 gallons per minute. Based on these data, the cost of water delivered to the zone is estimated to be just under $135 per acre-foot. For reference, this is nearly double the cost of the next most expensive water shown in Table III-1. EPANET modeling suggests that a properly operating pump at that location should supply water at a cost of about $28 per acre-foot.

Two options have been considered for reducing energy use at the Jurg Pump Station. The first option explored is replacement of the existing small pump. Replacement of the pump should be relatively straight forward assuming the existing pipes would not need replacement. The cost of replacing the pump is estimated to be about $6000. With an average pumping rate of 91 gpm the annual pumped volume is 147 acre-feet. Using $28 per acre-foot as the cost of water, the annual cost would be just over $4,100 and the payback period would be well under one year. The second option explored is to install a new 4-inch pipeline to serve as a supply to the Jurg Zone. The new pipeline would begin just above the hydroelectric facility at an existing PRV and would tie back in to the Jurg Zone supply pipeline just downstream of the existing pump station. This project would require about 2,000 feet of 4-inch pipeline at a projected cost of $132,000. This project would eliminate the pumping cost completely; however, there would also be a small amount of lost revenue due to the reduction in flow to the Hydro facility. Ignoring the lost revenue at the hydro facility, the payback period for this project is just under 7 years when compared to the existing annual cost.

ROTARY

Rotary Zone is located directly south of Bartholomew Zone and includes portions of Hobble Creek Canyon and a small area of Springville City to the northwest of the mouth of Hobble Creek Canyon. Water in Rotary Zone is supplied by Bartholomew Springs through the previously discussed hydroelectric facility located a short distance northwest of Rotary Tank. Water is conveyed from Rotary Tank to the mouth of Hobble Creek Canyon by a 24-inch transmission line. At the mouth of the canyon the transmission line makes a bend to the northwest and continues along the northeast edge of Springville City, ending at the Lower Spring Creek Tanks. Rotary Zone is currently the sole provider of water for the Jurg Zone and also for the Rotary PRV Zone. Depending on valve settings, excess water not used in the higher elevation zones can be used in the Lower Spring Creek and Hobble Creek Zones through connections with each zone.

During periods of low spring flow, water from the Lower Spring Creek Zone can be pumped back up to the Rotary Zone via a previously mentioned pump station located at the Lower Spring Creek Tanks. This connection allows water from the Lower Spring Creek Zone to be used in either the Rotary or Hobble Creek Zones. However, due to the cost of pumping, the pump station should only be used if there is insufficient water from Bartholomew Springs to supply the upper zones. Based on analyses of the calibrated model, no changes are needed for this zone.

ROTARY PRV

The Rotary PRV Zone receives all water from the Rotary Zone through two PRV connections. The first is near the mouth of Hobble Creek Canyon (3100 E Canyon Rd.) and the second is near the Lower Spring Creek Tanks (441 S 2080 E). Within the extended period model, the Canyon Road PRV is set at 60 psi and the 2080 E PRV is set at 55 PSI to match the field settings of the PRVs. These settings give a minimum zone pressure of about 55 psi near the 2080 E PRV and a maximum pressure of about 110 psi at the corner of 400 S and 1680 E. Based on the evaluation of the system, the PRV settings are appropriate and there are no recommendations for modifications to the Rotary PRV Zone.

CRANDALL

The Crandall zone is located just northwest of the Upper Spring Creek Zone and is supplied by a PRV connection with the Upper Spring Creek Zone at 1700 E Center St. The Crandall Zone then serves as the sole water supply to the Klauck and Nestle Zones. In terms of residential demand, the Crandall Zone is fairly small with an average demand of 136 gpm calculated from billing data. The residential connections in the Crandall Zone are located just northwest of the Lower Spring Creek Tanks. Most of the flow entering into the Crandall Zone is being conveyed to the Klauck and Nestle Zones. Demand for those zones is supplied by a transmission line extending north of the residential connections along the eastern edge of the City. Based on model observations, the Crandall Zone provides good service and no modifications to system operation are provided.

KLAUCK

The Klauck Zone receives water from two PRVs connected to the Crandall Zone at 880 E 400 N and 1125 N 800 E. In terms of demand, the zone is fairly small and has no outlets or additional sources. Due to these conditions, pressure variation within the zone is small. The 800 E PRV is set at 80 psi and the 400 N PRV is set at 90 psi. The current PRV settings provide good service and no modifications to system operation are provided for this zone.

HOBBLE CREEK

Zone Overview

Hobble Creek Zone is the third largest Springville pressure zone. The Hobble Creek Zone includes several sources (refer to Table III-1) and, in addition, can receive water from the Rotary Zone via a connection at the mouth of Hobble Creek Canyon. The overall capacity of the Hobble Creek Zone sources is much higher than the Zone's demand, even on peak days. During high demand periods the excess capacity from the Hobble Creek Zone provides supplemental water to the Lower Spring Creek and West Fields pressure zones. Based on a mass balance performed during this optimization analysis, about 1,500 gpm of flow is supplied by the Hobble Creek Zone through PRVs to the Lower Spring Creek zone during peak day flows.

The following sections provide an analysis of the Hobble Creek Zone. First, the existing cost hierarchy of the Hobble Creek sources is explored. Next, the findings obtained via the hydraulic modeling are explained. Following the discussion of the modeling results, recommendations for the Hobble Creek Zone are provided.

Cost Hierarchy of Hobble Creek Sources

At present, the least expensive water accessible to the Hobble Creek Zone is the Bartholomew spring water available through the PRV connection with Rotary Zone. The next two least expensive water sources are the 900 South and the Canyon Road Wells. Currently, Burt Springs and the 1000 South Well are the highest priced active sources in the Hobble Creek Zone. Evergreen Well is not currently active and, consequently, flow data were unavailable for that source.

The cost hierarchy outlined above will be affected by planned improvements to Burt Springs. Water from Burt Springs is pumped from the spring collection into the Hobble Creek Tanks. Because the flow rate of the springs is variable, the flow rate of Burt Springs pump must also be varied in relation to the spring flows. Flow control of the pump is currently achieved by using a valve to throttle flow. Flow throttling creates headloss which pushes the operation point of the pump down along the pump curve. Unfortunately, the headloss represents lost energy and increases the cost of operating the pump. Furthermore, controlling the pump by means of a control valve results in the pump operating away from its best efficiency point. The current energy cost of water for Burt Springs is about $64 per acre-foot based on power billing records and production records submitted to the DWR. A currently planned project will replace the Burt Springs pump and also add a variable frequency drive (VFD). The VFD will allow the flow rate to be controlled without the use of a control valve. It is estimated that after the improvements have been installed, water from Burt Springs will have an energy cost of about $7 to $8 per acre-foot and Burt Springs will be the City's least expensive pumped source. Once the project is complete, the City should fully utilize their share of the Burt Springs flow before any of their other pumped sources. After the improvements have been completed at Burt Springs, the cost hierarchy from least expensive to most expensive source will be as follows for the Hobble Creek Zone:

Bartholomew Springs < Burt Springs < 900 South Well < Canyon Road Well < 1000 South Well

In addition to the Burt Springs improvements, the City is also planning improvements to the 900 South Well. The improvements include adding a VFD, a 400 HP motor, and an additional stage to the existing pump. The VFD is intended to be set to maintain a constant pressure at the well. The current cost of water from the 900 South Well is $45 per acre foot based on power billing data and production data. These improvements are not expected to substantially change the cost of pumping for the 900 South Well. At a cost of $45 per acre foot, the 900 South Well is one of the cheaper pumped sources for the City.

Hydraulic Model Observations

The Hobble Creek Zone was analyzed using the extended period model in order to identify areas where level of service or energy efficiency improvements could be applied. The following items were identified:

- High velocities and pressure fluctuations occur around the 900 South and 1000 South Wells, particularly between the wells and nearby PRVs.
- Large pressure fluctuations and low pressures occur in the Evergreen area of the Hobble Creek Zone.
- Pressure fluctuations and low pressures occur in the areas just north of Canyon Road Well.
- Throttling of the 1000 South Well is achieved by using a control valve.
- 1500 gpm of water is provided by the Hobble Creek Zone to the Lower Spring Creek Zone during peak day flows.

The high velocities and pressure fluctuations around the 900 South and 1000 South Wells are largely a consequence of the wells turning on and off. When the wells turn on, flow velocities in the pipes between the wells and the nearby PRVs are high because much of the water flows through the nearby PRVs and into the Lower Spring Creek zone. In addition to the high flow velocities, the wells turning on and off also cause large pressure variations. The 900 South Well in particular has a large capacity and greatly affects the pressures in the region near the well.

The Evergreen area is the most distant part of the Hobble Creek Zone from the Hobble Creek Tanks. Because of the distance from the tanks, the diurnal pressure variation for the area is relatively high. Pressure resulting from the operation of the 900 South and 1000 South Wells serves to further increase the variation in the area. During high demand conditions, pressures in the Evergreen area dip to about 50 psi.

Canyon Road Well has been used to supply water to the Hobble Creek Zone and also to the Lower Spring Creek Zone via a SCADA controlled valve in 400 South. Velocities were observed to be particularly high just northwest of the well when used to supply water to the Lower Spring Creek Zone. However, under both usage scenarios some localized high velocities were observed with accompanying diurnal pressure swings.

Due to quality constraints, along with a limitation placed by the Division of Water Rights (DWR) the 1000 South Well is limited to a maximum flow of 550 gpm. The pump and motor currently installed in the well have a design flow of 800 gpm. In order to reduce the flow, a control valve is used to throttle the flow. As with Burt Springs, throttling the 1000 South Well results in increased energy costs.

Mass balance calculations indicate that the average flow supplied by the Hobble Creek Zone to the Lower Spring Creek Zone during peak day is about 1,500 gpm. There is nothing fundamentally wrong with supplying flow to the Lower Spring Creek Zone through the PRVs. For example, during low flow periods, it may be possible to supply all of the water in Springville using spring water. Spring water has no production cost and, additionally, headloss is small as a consequence of low pipeline velocities. However, during peak demands, the elevated PRV flows result in excessive demands on the Hobble Creek Tanks. Water from the tanks must traverse the entire zone to reach the PRV connections with the Lower Spring Creek Zone. While not overly large, the minor increases in velocity result in comparatively larger increases in headloss due to the distance the water travels.

Recommendations

The following recommendations address the shortcomings outlined in the previous section. Several of the shortcomings are interrelated and, as a result, the solutions described herein generally apply to multiple deficiencies. Following each described recommendation is a summary explaining the effects of the suggested changes.

During the course of the optimization study it was observed that when the 900 South Well was active, about half the water from the well went directly through the PRVs at 900 South 800 East and 1000 South 600 East down to the Lower Spring Creek Zone. The well water combines with other water flowing through the PRVs to create a region with high flow velocities. Based on these observations, the possibility of pumping water directly into the Lower Spring Creek Zone was investigated. Findings from the extended period modeling indicate that the pumping cost for the 900 South Well would decrease from $45 to about $29 per acre foot by pumping directly to the Lower Spring Creek pressure zone. Over the last several years pumping costs for the well have varied from about $47,000 in 2011 up to $106,000 in 2013. With a cost savings of about 36%, the corresponding annual savings would range from just under $17,000 to slightly over $38,000. In order to move the well to the Lower Spring Creek Zone the following changes would be needed:

- Close the valve east of where the 900 South Well connects into the 16” Pipeline in 900 South. The 16-inch pipeline west of the connection point with the 900 South Well will then become the transmission pipeline to the Lower Spring Creek Pressure Zone.
- Construct a bypass pipeline around the PRV Station at 800 East and 900 South so that flows from the 900 South Well can flow into the Lower Spring Creek Zone without going through the PRV.
- Add a connection across 900 South at 1000 East to tie the 16” pipeline remaining in the Hobble Creek Zone to the 6-inch diameter pipeline on the south side of 900 South.

In addition to the aforementioned changes, a VFD should be installed at the 900 South Well as had been previously planned. The VFD should be set to maintain a pressure of 80 psi with operation of the well also governed by the water level in the Lower Spring Creek Tanks. After moving the 900 South Well to the Lower Spring Creek Zone, it will become the City’s least expensive well source. For that reason, the 900 South Well should be set to turn on and off at higher water elevations than the other wells in Lower Spring Creek Zone. Recommended tank settings are provided later in this report within the section pertaining to the Lower Spring Creek Zone.

Along with transferring the 900 South Well to the Lower Spring Creek Zone, the PRVs connecting the Hobble Creek and Lower Spring Creek Zones should be set so that no flow is allowed through during normal operating conditions. Instead, the PRVs should be set to operate as fire-flow PRVs which only permit flow under emergency conditions. Within the extended period model, the 1150 E 50 N PRV was modeled with a pressure setting of 63 psi and the 1000 S 600 E PRV was modeled with a setting of 65 psi. These settings were found to provide good performance.

Based on our understanding of the network it should be straightforward for the City to maintain the ability to switch the 900 South Well back to the Hobble Creek Zone, if needed. In this manner, the City will be able to benefit from the cost savings of pumping to the lower zone while preserving flexibility to meet demands in the Hobble Creek Zone. The other planned improvements for the 900 South Well, including the 400 hp motor and additional pump stage, do not provide any benefits when pumping to the Lower Spring Creek Zone. Both improvements were planned around pumping to the Hobble Creek Tanks and would allow additional pumping capacity if it ever becomes necessary to move the well back to the Hobble Creek Zone. However, since it is expected that the normal operation of the 900 South Well will be in the Lower Spring Creek Zone, neither upgrade is recommended at this time.

The current capacity of the 900 South Well is about 2,800 gpm. With the proposed changes of moving the 900 South Well to the Lower Spring Creek Zone, the well capacity will increase to about 3,200 gpm. Adequate supply would still be maintained in the Hobble Creek Zone by reducing or eliminating flow through the PRVs connecting the two zones and by increasing flow from Rotary Zone to Hobble Creek Zone through the valve at the Hobble Creek Tanks. The added flow from Rotary Zone will be available by correspondingly decreasing the flow from

Rotary Zone to Lower Spring Creek Zone.

The 1000 South well is currently operated by manually turning the well on and off as needed. The well is throttled with a control valve so that it flows at about 550 gpm while pumping. Production from the well is limited to 550 gpm due to water quality and regulatory constraints. With the throttling, the energy cost of pumping the water is about $72 per acre-foot. Using the extended period model, it was calculated that the energy cost for pumping the water without the added headloss would be about $56 per acre-foot. The additional headloss can be avoided by installing a VFD at the 1000 South well or by installing a pump that is sized to produce 550 gpm without throttling. The first option investigated was to add a VFD with a setting to maintain pressure. Using a VFD to maintain pressure at the 1000 South Well benefits the Evergreen area by raising overall pressures and attenuating the daily pressure variation. Initial modeling was performed using a pressure setting of 105 psi. However, during high demand periods it was observed that flows from the well spiked to 950 gpm in order to maintain the pressure. Setting the VFD to a lower pressure was considered, but the effectiveness of the pressure control was reduced. Based on these findings, and in consideration for the Well's flow constraints, a pressure maintaining VFD is not recommended. Instead, a flow regulated VFD should be considered or a pump sized to produce 550 gpm without throttling.

The 1000 South well has not been used heavily; however, data from the Utah Division of Water Rights (DWR) show that 175.2 acre-feet of water was pumped from the well in 2012 and 152.4 acre-feet was pumped in 2011. At the above referenced price savings the cost savings in 2012 would have been just over $2,800 and in 2011 it would have been about $2,400. Before 2011 that next most recent year of usage was in 2007. The payback period is strongly dependent on the volume of water used from the source. Based on model observations, it is believed that usage of the well after implementing the described improvements will be similar to that recorded in 2011 and 2012. With an estimated cost of $48,000, the payback period for adding a VFD is about 18 years.

The proposed changes to the 900 South and 1000 South Wells, along with restricting the PRV flows from the Hobble Creek Zone to the Lower Spring Creek Zone, provide several benefits in addition to cost savings. One benefit is reduced flow along the transmission lines between the Hobble Creek Tanks and the PRV connections with the Lower Spring Creek Zone. The reduction in flow lowers headloss and helps to reduce pressure variation throughout the Hobble Creek Zone. Specific areas that are benefitted by the lower pressure variation are the areas around the 900 South and 1000 South wells, the Evergreen area, and the area northwest of the Canyon Road Well. The reduction in pressure variation was of particular benefit to the Evergreen area. As a result of distance from the Hobble Creek Tanks and high flow velocities, the Evergreen area has up to 25 psi of pressure variation within the model of the existing system. At the same time, low pressures in the Evergreen area reached about 52 psi. Removing the added pressure variation caused by the pumps helps to keep the diurnal variation to more reasonable levels. The proposed changes to the wells and PRVs helped reduce pressure variation to about 16 psi with low pressures of 64 psi in the Evergreen area.

Based on the demand allocation within the Hobble Creek Zone, sufficient water should be available without the need to operate the Canyon Road Well. As Canyon Road well is one of the higher cost sources, it is recommended that Canyon Road Well should be used as a backup source. In months were the well is not pumped at all, the City will be able to avoid paying a demand charge for usage of the well.

With the above outlined recommendations implemented, the Hobble Creek Tanks operate very well with good turnover. The largest water sources for the Hobble Creek Zone are Burt Springs and Bartholomew Springs. The two springs can provide a combined flow over 2,000 gpm. Both sources discharge directly into the Hobble Creek Tanks before becoming available to the rest of the Zone. As a result, the turnover for the tank is just under 3 MG daily out of a total volume of about 4 MG.

Summary of Recommendations:

- Maximize flow from Burt Springs.
- Move the 900 South Well to the Lower Spring Creek Zone.
- Install a VFD on 1000 S Well and set the VFD to maintain a flow of 550 gpm or install a new motor that allows that well to produce 550 gpm without throttling.
- PRVs connecting the Hobble Creek and Lower Spring Creek Zones should be operated as emergency PRVs with no flow under normal operating conditions.
- Under existing conditions, Canyon Road Well should be used as a backup water source. In months that the well is not needed, the demand charge will be saved.

LOWER SPRING CREEK

Zone Overview

The Lower Spring Creek Zone is the largest Springville pressure zone In terms of demand. The zone includes several sources as listed in Table III-1. In addition, the Lower Spring Creek Zone receives water from PRV connections with the Hobble Creek Zone and also spillover water from Upper Spring Creek Tank. The Lower Spring Creek Zone also has a connection with the Rotary Zone at the Lower Spring Creek Tanks. On the other hand, the Lower Spring Creek Zone provides water to the West Fields Zone through PRV connections along the west edge of the Lower Spring Creek Zone. The West Fields connections serve as the sole source of supply for that zone.

The following sections provide an analysis of the Lower Spring Creek Zone. First, the existing cost hierarchy of the Hobble Creek sources is outlined. Next, the findings obtained via the hydraulic modeling are discussed. After discussing the findings from the hydraulic modeling, recommendations for the Lower Spring Creek Zone are presented.

Cost Hierarchy of Lower Spring Creek Sources

Due to the connections with higher pressure zones, every Springville source can contribute to meeting the demand within the Lower Spring Creek Zone. Aside from the sources located in higher zones, sources located within the Lower Spring Creek Zone include: Konold Springs, 400 South Well, and 200 North Well. Konold Springs feeds into the Lower Spring Creek Tanks by gravity and has no associated production cost. The 400 South well, with a cost of $39/ acre-foot, is currently the City's least expensive well. In the future, if the 900 South Well is moved to the Lower Spring Creek Zone, it is projected to become the least costly well at a price of $29/acre-foot. Water from the 200 North well has a cost of $56/acre-foot, making it moderately priced. As with the other Springville pressure zones, spring water should be utilized first. Moving into summer, as demands increase and pumping wells becomes necessary the lower cost wells should be used first.

Hydraulic Model Observations

As presently operated, the Lower Spring Creek Zone provides good service to most connections within the zone. Nonetheless, a few areas were identified as candidates for efficiency improvements. The following items were identified:

- Large pressure variations and high velocities occur when the 200 North Well turns on and off
- Moderate diurnal pressure swings occur in the extreme northwest and southwest portions of the zone

The 200 North well is fairly large, with a capacity of about 3,000 gpm. As a result, the Well has a large effect on the surrounding area. Depending on well operation, modeling shows that pressures near the well vary from 82 to 105 psi. The 200 North Well is currently operated using a VFD set to 102 psi.

With respect to the bottom of the Lower Spring Creek Zone, moderate pressure variations were observed in the northwestern and southwestern portions of the Zone. Modeling indicates the primary culprit of the large variation is the distance of these areas from the sources and Lower Spring Creek Tank. Ancillary causes for the variation include the operation of the 200 North well (northwestern area) and unbalanced PRV settings (southwestern area).

Recommendations

In order to improve the performance of the Lower Spring Creek Zone, a few changes are suggested. Several of the suggestions pertain to operational changes and would require no capital expenditures. As with the Hobble Creek Zone, recommendations are provided and then the effects of the recommendation are explained.

The first recommendation for the Lower Spring Creek Zone is that the PRVs connecting to the

West Fields Zone should be balanced. Based on the calibration data provided, it appears that the PRV located at 650 W 1600 S is set to a higher head than the other PRVs, creating a preferential path. The preferential path results in higher flows down through the southern region of the Lower Spring Creek Zone. The higher flow velocity results in larger headlosses and diurnal pressure variations. It is recommended that all of the West Fields PRVs should be set to about the same head with a mild preference to the 400 South PRV supplied by the 30-inch transmission line. Reducing the flows to the pipelines along the north and sound extremities of Lower Spring Creek Zone reduces the diurnal pressure variation to those areas. Recommended settings are as shown in Table III-3.

In order to moderate the pressure and velocity spikes with the 200 North well, it is recommended that the pressure setting at the well be reduced to 95 psi. The lower pressure setting reduces the impact of well operation while also reducing the overall production of the well. One positive benefit of reducing production from the 200 North Well is that production from less costly sources such as the 400 South and 900 South well can be maximized. Additionally, modeling suggests that reducing the pressure setting will result in a savings of about 8% to 10% in per volume cost of the water produced by the well.

TABLE III-3
LOWER SPRING CREEK / WEST FIELDS
RECOMMENDED PRV SETTINGS

PRV Location	Setting (psi)
900 N Main	80
400 W 400 N	79
650 W Center	80
650 W 400 S	81
650 W 1600 S	80

The tank settings used in modeling the proposed changes to the Lower Spring Creek Zone are shown in Table III-4.

TABLE III-4
MODELED LOWER SPRING CREEK TANK SETTINGS

WELL	ON (FT)	OFF (FT)
200 North	17.0	19.0
400 South	17.5	21.0
900 South	18.0	22.0

These elevation settings were found to give good performance with the water level varying between 12 and 20 feet in the 2 MG Lower Spring Creek Tank. At the lowest elevation, about 1

MG of reserve capacity remained in the tank. The 400 South and 900 South Wells remained on continuously while the 200 North Well cycled on and off according to water level.

NESTLE

Due to industrial demands, the Nestle Zone has relatively high water requirements compared to its size. The Nestle Zone receives all water from a connection with the Crandall Zone. Performance of the Nestle Zone has generally been good. Average zone pressures are about 110 psi with 5 psi of variation between high and low pressures. However, because the Nestle Zone depends solely on a connection with the Crandall Zone it is entirely dependent on Spring Creek Springs and a single pipeline which stretches along the northeast side of the city. If the Springs do not produce sufficient water, then the City has to use the booster pumps to pump water from the Lower Spring Creek Zone to the Upper Spring Creek Zone.

Model simulations were performed in order to explore the possibility of providing water to the Nestle Zone using Lower Spring Creek Zone water. Allowing water from the Lower Spring Creek Zone to be used would add needed redundancy. The reviewed scenario which provided the best utility to the distribution system was to reroute the existing Nestle feed line to the Lower Spring Creek Zone and then add a new PRV connection between the Lower Spring Creek Zone and the Nestle Zone. To accomplish these changes the existing Crandle/Nestle connection would be set to the head of the Lower Spring Creek Zone and the existing supply line would be connected to the Lower Spring Creek Zone. The new PRV connection between the Lower Spring Creek Zone and the Nestle zone would be installed at about 1400 N Main St. These improvements would provide another delivery point for water into the Lower Spring Creek Zone while transferring the source of the Nestle Zone from the Crandle Zone to the Lower Spring Creek Zone. The new connection helps to reduce pressure variation in the northwest corner of the Lower Spring Creek Zone and adds redundancy.

One alternative to the above modifications that would allow the City to provide source redundancy to the Nestle Zone is to add a simple cross connection at 1400 North Main Street between the two zones. During a recent pipeline installation project, the City decided to add such a connection because it was relatively easy to add the connection on to an existing project. The installed connection is controlled by a manually operated valve that is kept closed during normal operation. During an emergency the valve can be opened to provide source redundancy to the Nestle Zone. Both the PRV alternative outlined above and the manually controlled connection are able to provide source redundancy to the Nestle Zone. Each of the alternatives has advantages. The primary advantage to adding a PRV is that it would allow water from the Crandle Zone to be used as a supplementary source in the northwest area of the Lower Spring Creek Zone. The extra source in that region increases pressures on high demand days and reduces diurnal pressure variation. One major advantage of the manually controlled connection is that it has already been installed and the installation cost was much lower than adding a PRV. Moreover, while the PRV option would improve pressures in the northwest area of the Lower Spring Creek Zone, the current pressures are acceptable. Under normal conditions, the manually operated valve will have no effect on system performance. With the valve open, pressures in the northwest area will be slightly lower, while the pressure in the Nestle Zone will rise by 10 to 15 psi.

One concern for making either of these changes is that a chlorine residual of 0.4 mg/L needs to be maintained at the Stouffer's food plant. The chlorine residual is easily met by the Crandle Zone because all the water from that zone originates at the Spring Creek Springs source, which is chlorinated. Conversely, the wells located in the Lower Spring Creek Zone are not chlorinated. During seasons with high well use, the chlorine residual provided by the Lower Spring Creek Zone would not be sufficient. It may be possible to add a chlorine injector to a Lower Spring Creek source or a chlorine booster at the proposed 1400 North PRV connection. The travel time for water to move from the intersection of State Street and 1400 North to a location just south of the Stouffer's food plant at about 750 West 1400 North is about 30 minutes during peak day flows. Therefore, adding a chlorine booster at that location would provide a minimum contact time of 30 minutes. If the supply line to the food plant is on the north side of the building, the contact time would be at least 1 hour.

WEST FIELDS

The West Fields Zone is the second largest pressure zone by demand and is currently served entirely by PRV connections with the Lower Spring Creek Zone. The West Fields Zone appears to be performing well with a lowest pressure of about 75 psi and about 3-4 psi of diurnal pressure variation. Compared to the other two large Springville pressure zones, the West Fields Zone is the least developed. As a result, much more growth is expected in the West Fields Zone than in the Lower Spring Creek and Hobble Creek Zones. The City does not currently have any storage or sources located in the West Fields Zone. As the West Fields Zone continues to grow and demand increases, future source and storage may be considered in the West Fields Zone. Adding sources and storage would allow the city to avoid pumping water higher than necessary and then wasting energy as water flows through PRVs down to the West Fields Zone.

The majority of the recommendations for the West Fields Zone will affect multiple zones. For this reason, most of the discussion regarding West Fields Zone project has been included within previous sections. One alternative that has not yet been explored is moving an existing Lower Spring Creek source to the West Fields Zone. The 400 South well was looked at specifically because it provided the most direct route to the lower zone. Pumping directly to the West Fields Zone would allow the well to pump to a lower head, saving energy that is currently being dissipated by PRVs. Based on power records and modeling pumping costs could be reduced by about 25% by pumping directly to the West Fields Zone. Billing data for the 400 South Well gives an annual cost of $38,444 for July 2011 to June 2012. At 25% the annual savings would be $9600. About 8,900 feet of pipe would be needed to connect the 400 South Well to the West fields zone near the existing 650 W 400 S PRV station. In order to keep pipeline velocities below 5 fps, a 16-inch diameter pipeline would be needed. The estimated cost for the new pipeline is about $1.2 million. Based solely on a base cost for the pipeline and ignoring additional costs for pump modifications, street crossings, etc., the payback period would be about 125 years. Based on these preliminary calculations, moving a Lower Spring Creek source to the West Fields Zone was found to be infeasible.

Notwithstanding the advantages of having dedicated sources and storage for the West Fields Zone, additional sources and storage located directly in the zone may not be practical. Due to the location of the West Fields zone in relation to the higher elevation foothills northeast of Springville, dedicated storage for the zone would require lengthy transmission lines. Moreover, past experience suggests that well production decreases while moving westward in Springville. If a good producing well was located within the West Fields Zone, the well could be used as a peaking source on high demand days.

CHAPTER IV

WATER QUALITY EVALUATION

Using the calibrated extended period model, simulations were performed to examine the water quality within the Springville distribution network. Water age and chlorine concentration were modeled using the Existing Model and also with the proposed recommendations implemented (Proposed Model). Each water quality parameter analyzed with the models is discussed in the following sections.

WATER AGE EVALUATION

While chlorine is an effective disinfectant in controlling many microorganisms in drinking water, it reacts with natural material found in drinking water to form potentially harmful disinfection byproducts (DBPs). Although the risk of becoming ill from microbial pathogens is tens of thousands of times greater than the risk of becoming ill from DBPs, it is enough of a concern that the Environment Protection Agency (EPA) has developed rules to balance the risks between microbial pathogens and DBPs. A drinking water system needs enough chlorine to destroy pathogens but also not produce excessive DBP.

The extended period model was used to predict the areas in the water system that have the highest potential for DBP production. The potential for DBP production is higher in warmer and older water, so a water age model typically follows a similar pattern to where DBP production has the highest potential. The month that typically has the highest DBP levels in Utah is October. This is because the water is still relatively warm and water use is less than during the summer. Water age was calculated for every location in the system by running the model to simulate several days in October. The locations with the poorest circulation also have the oldest water. Figure IV-1 illustrates the results of the water age model scenario run for 96 hours using the Existing Model for October. Figure IV-2 illustrates the results of the water age model scenario run for 96 hours using the Proposed Model for October. Overall, most of the system receives fresh water every three days.

Several interesting comparisons can be made between the water age in the Existing model and in the Proposed Model. Some of the differences in age are related to the status of pump operation while other differences are related to changes in source utilization. The oldest water in both zones is generally located in dead end lines and along the westerly edge of the West Fields Zone. In comparing the water age of the two models in the Hobble Creek Zone, the water in the Existing Model was generally older than in the Proposed Model. Within the Existing Model, Hobble Creek Zone water was primarily supplied by water from sources located within the Zone. Within the Proposed Model, Hobble Creek Zone water was supplied by a combination of water from sources located within the Hobble Creek Zone and water from Rotary Tank. Conditions were reversed with respect to water age in the Lower Spring Creek and West Fields Zones, where water age was higher in the Proposed Model.

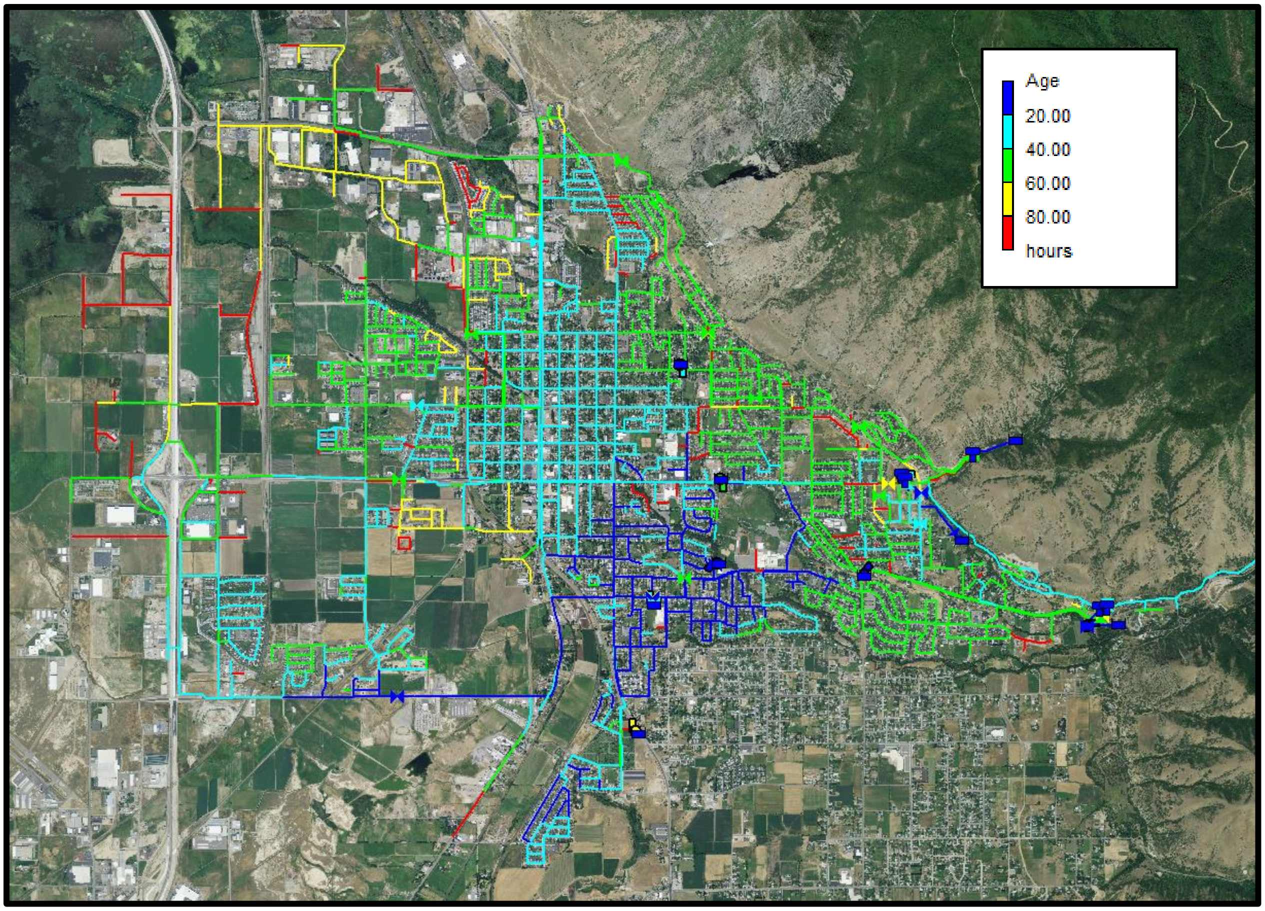


FIGURE IV-1 Existing Model Water Age with October Demands

Figures IV-1 and IV-2 represent snapshots of the model results. Because the two models operate with different control settings, pump operation varies between the two models. Within Figure IV-1 the effect of the 900 South and 1000 South Wells is evidenced by the dark blue coloration immediately around the two pumps. In Figure IV-2, the 900 South Well is just turning on. Differences in pump operation are the largest cause of differences between the Existing and Proposed models with respect to water age in Lower Spring Creek and West Fields Zones. A minor contribution is also made by changes in source utilization, with increased water from the Rotary Tank being directed to the Lower Spring Creek Zone in the Proposed Model.

Dead end lines have the worst circulation in the model. It is recommended that the City use the water age model to make sure DBP sampling is occurring at the locations with the highest DBP production potential. It is also recommended that the City use the water age model to develop an effective flushing plan. The goal of a flushing plan is to create flow velocities within the pipes sufficient to remove loose sediments and to scour and clean pipe walls. In order to achieve that goal, a minimum velocity criterion of 3 ft/s is suggested.

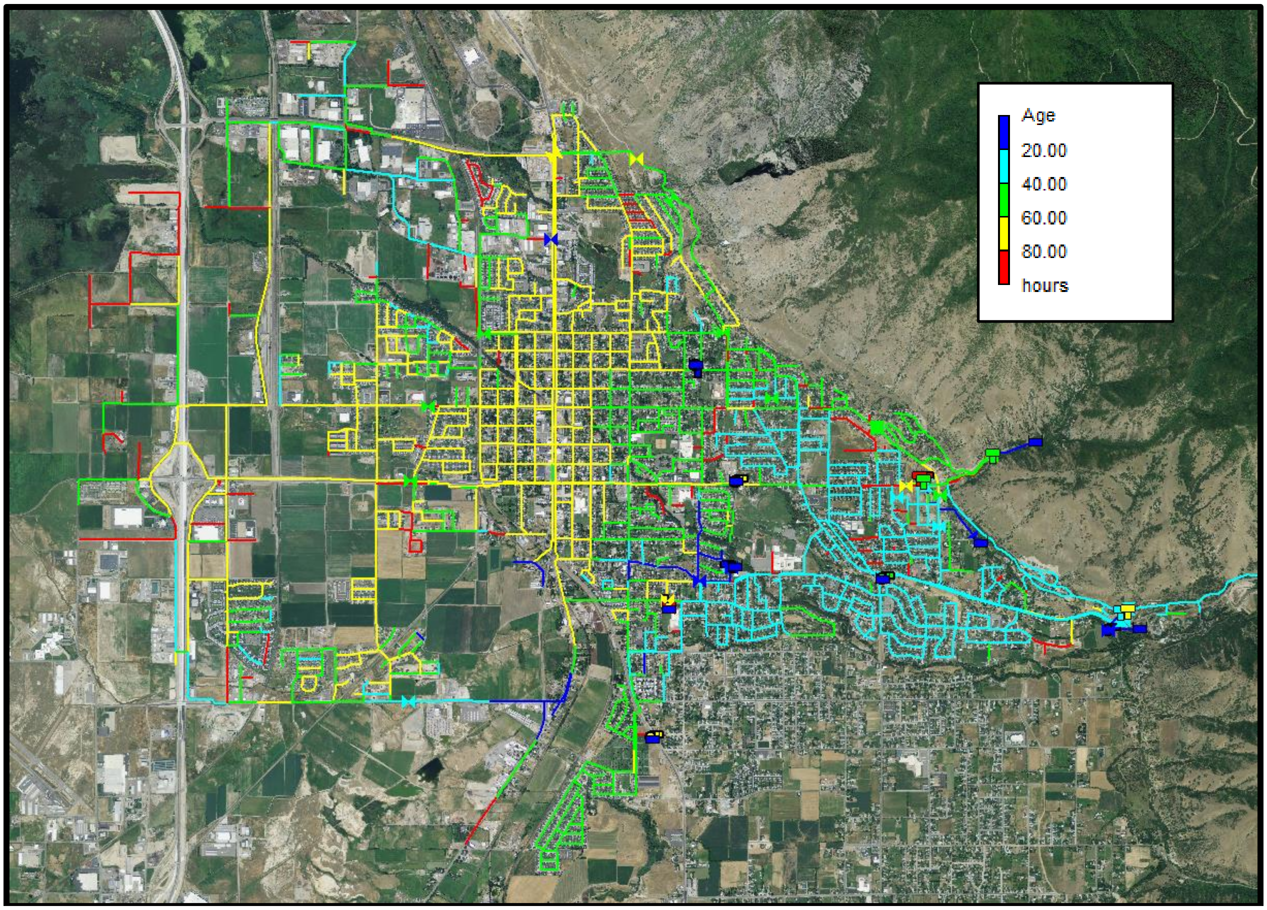


FIGURE IV-2 Proposed Water Age Model with October Demands

CHLORINE RESIDUAL EVALUATION

The extended period model was also used to analyze chlorine residual over time in the drinking water system. Chlorine residual is the amount of chlorine remaining in treated water after a specific time has passed. Chlorine dosing rates were set at Spring Creek Springs, Rotary Tank, and Burt Springs. Dosing rates were adjusted so that the model reproduced the general range of chlorine concentrations measured within the Springville distribution network. Dosing rates of 0.7 mg/l were input for Spring Creek Springs and Burt Springs while 1.1 mg/l was used for Rotary Tank. Chlorine residuals are influenced by how much organic material is in the water and can vary greatly depending on seasonal variations in water quality. The model uses a bulk rate coefficient to calculate the decay reaction of chlorine. The bulk rate coefficient used for Springville was -0.1 per day. Actual decay rate in the system varies depending on the organic content of the water.

The model was run long enough for the chlorine concentrations to stabilize which took about three days depending on the water demand. Field test results confirmed patterns produced in the model (see Appendix D). In order to maintain consistency with the water age modeling, the chlorine modeling was performed using October demands. One additional simulation was completed using summer demands with the proposed model. Figure IV-3 shows the Chlorine residual for the Existing Model using October demands.

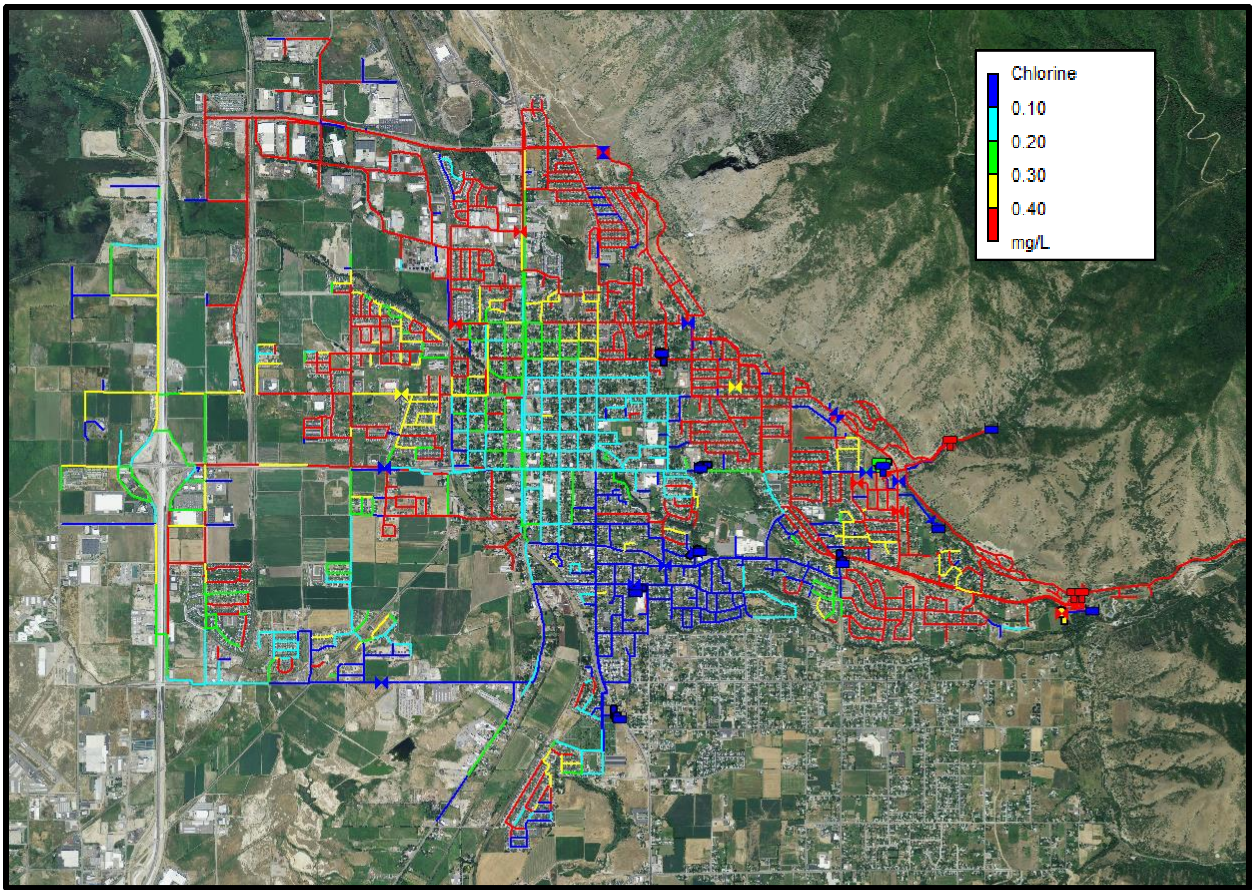


FIGURE IV-3 Existing Model Chlorine Residual with October Demands

Higher concentrations of chlorine residual were found in areas supplied by spring water. As expected, areas near the wells with no chlorine dosing have a low chlorine residual. Dead end lines with low demands have low chlorine residuals and are also locations that tend to have the highest water age and potential for DBP production. For example, dead-end lines around the periphery of the system have low chlorine residual, supporting the need for increased circulation in these areas. The full utilization of equalization storage over several days may help with managing water age. Areas supplied by well water also have low chlorine residuals.

Figure IV-4 shows the Chlorine residual for the Proposed Model, also using October demands. Figures IV-3 and IV-4 both represent snapshots of the model results after 96 hours. A comparison between the two Figures clearly shows the influence of the 900 South Well on chlorine residuals in the region around the well. Although the two images were captured at the same model runtime, the wells are not in sync because of the different control settings. In the Existing Model figure, the well has been on for some time at the moment when Figure IV-3 was captured. The well has been feeding water out in to the Hobble Creek Zone and down into the Lower Spring Creek Zone through the 900 South and 1000 South PRVs. In Figure IV-4

(Proposed Model) the well is just turning on and is supplying water solely to the Lower Spring Creek Zone.

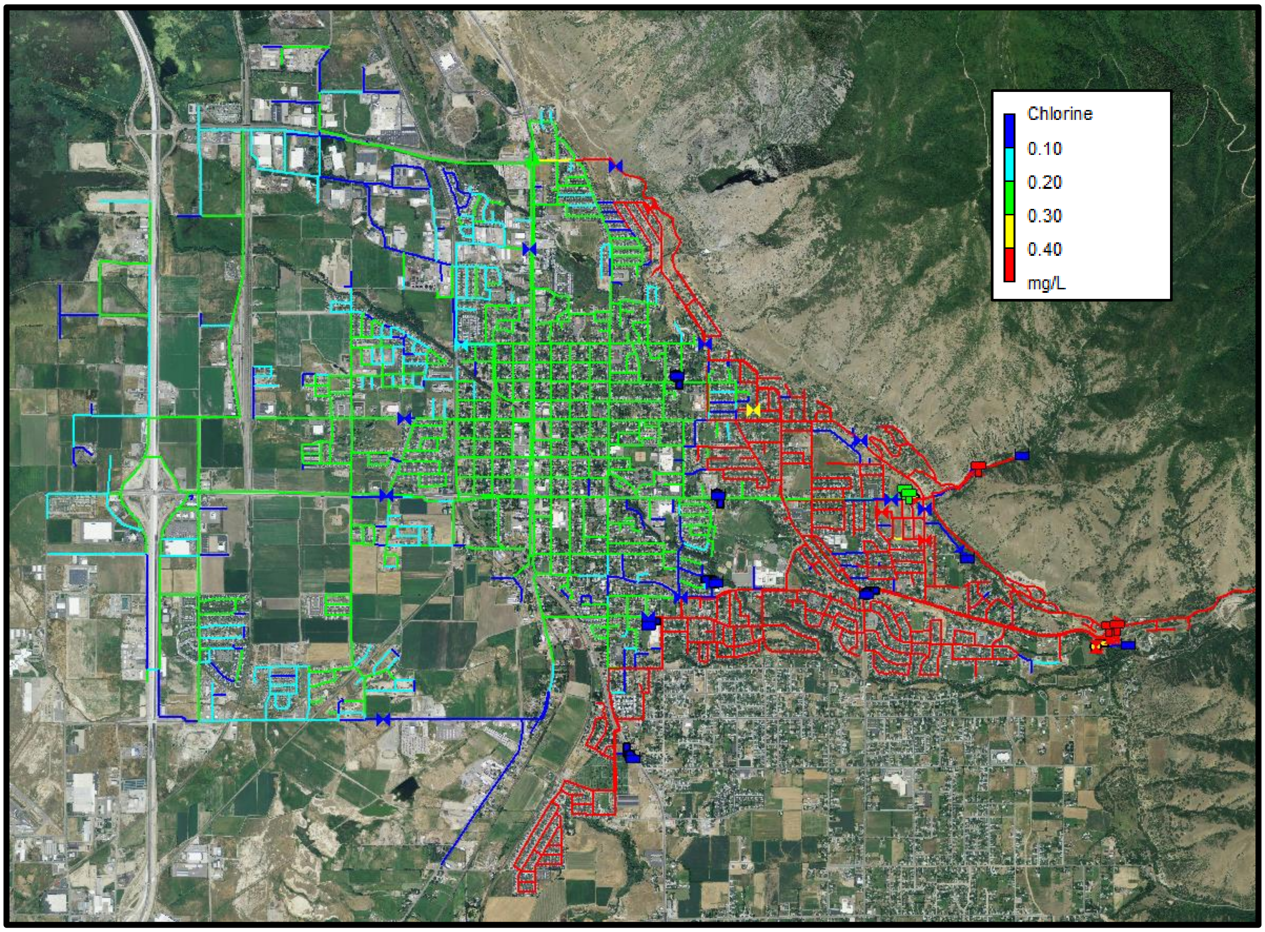


FIGURE IV-4 Proposed Model Chlorine Residual with October Demands

Figure IV-5 shows the Chlorine residual for the proposed model using summer demands. Implementation of the proposed recommendations will result in more spring water being used in the Hobble Creek Zone and more well water being used in the Lower Spring Creek Zone. A consequence of the shift is that higher chlorine residuals are maintained in the Hobble Creek Zone while the chlorine residual is lower in the Lower Spring Creek and West Fields Zones. In order to raise the residual in the Lower Spring Creek and West Fields zones it would be necessary to chlorinate at some of the Lower Spring Creek well sources. It is recommended that the City use the model to refine a chlorination plan that best meets the goals of the City.

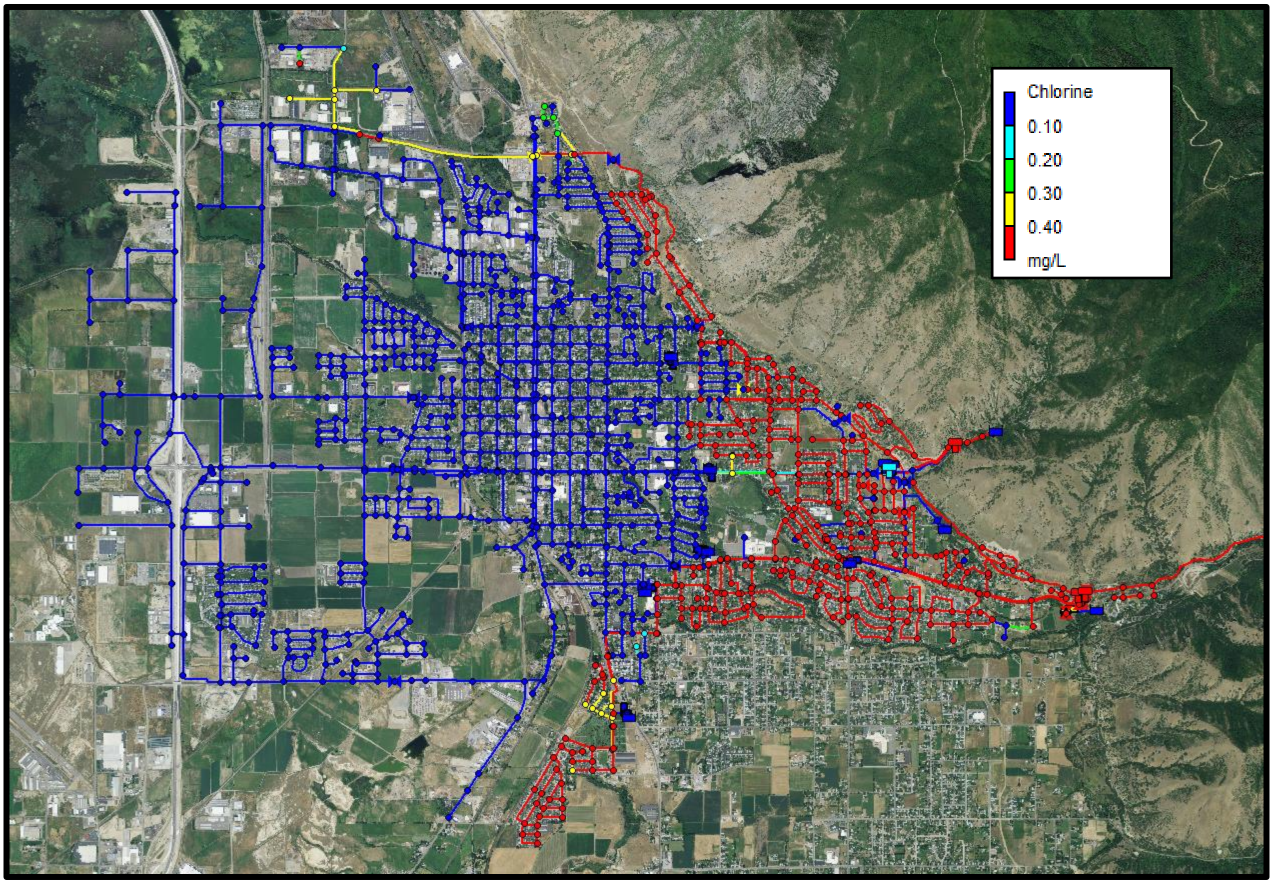


FIGURE IV-5 Proposed Model Chlorine Residual with Summer Demands

CHAPTER V

SUMMARY

The purpose of this water system optimization analysis is to build an accurate extended period hydraulic model and use the model to develop specific operational recommendations to the City to improve efficiency by optimizing the use of water sources, storage, pumps, and energy, and improving system performance and water quality. The analysis focused on the extended period hydraulic model which was calibrated from the peak water use month in the summer of 2012.

Overall, the water system operates very well. In general, velocities at peak instantaneous flow rates are relatively low and pressure fluctuations are small. However, system optimization measures were developed based on the following overall optimization goals 1) Increase efficiency of electricity usage 2) Maximize the use of equalization storage, and 3) Maintain normal pressures throughout the system at all customer connections. In addition to these system optimization goals, the water model was used to analyze water quality. The purpose of the model is to provide ideas and tools for City personnel to implement additional system optimization measures that will provide sustainable system performance, cost savings, and water quality improvements.

Within the report, the following recommendations have been presented:

- Flow from Spring Creek Springs, Bartholomew Springs, and Konold Springs should be maximized because they have no associated power costs.
- Less costly sources should generally by used before more costly sources.
- **EITHER** the existing Jurg pump should be replaced with a pump designed to operate at optimal efficiency **OR** a 4-inch pipeline should be installed between the Rotary Hydro facility and the Jurg Pump station to supply water to the Jurg Zone and eliminate the need for the pump station
- The 900 South Well should be moved to the Lower Spring Creek Zone and set to operate based on a pressure setting and the water level in the Lower Spring Creek Tanks
- A VFD should be installed on the 1000 S well and set to maintain a flow of 550 gpm or the pump and motor should be modified to produce 550 gpm without throttling
- PRVs connecting the Hobble Creek and Lower Spring Creek zones should be operated as emergency PRVs with no flow under normal operating conditions
- The Canyon Road well should be used as a backup water source
- PRVs connecting the Lower Spring Creek Zone to the West Fields Zone should be set to about the same hydraulic grade line elevation, with a slight preference to the 400 South PRV.
- The City should consider connecting the existing Nestle Zone supply pipeline to the Lower Spring Creek Zone and then connecting the Lower Spring Creek Zone to the Nestle Zone with a PRV.

REFERENCES

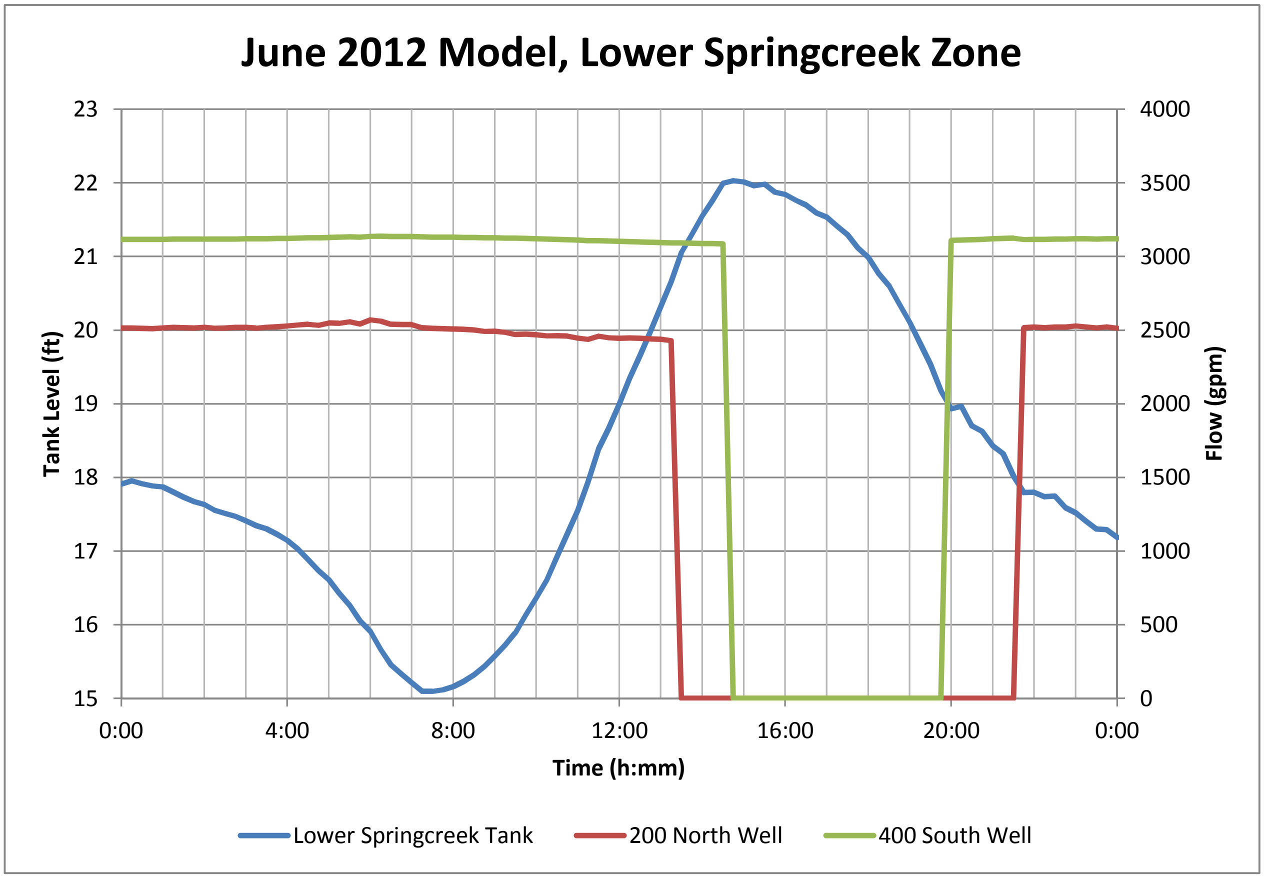
State of Utah, Utah Administrative Code, Title R309. Drinking Water, February 2010

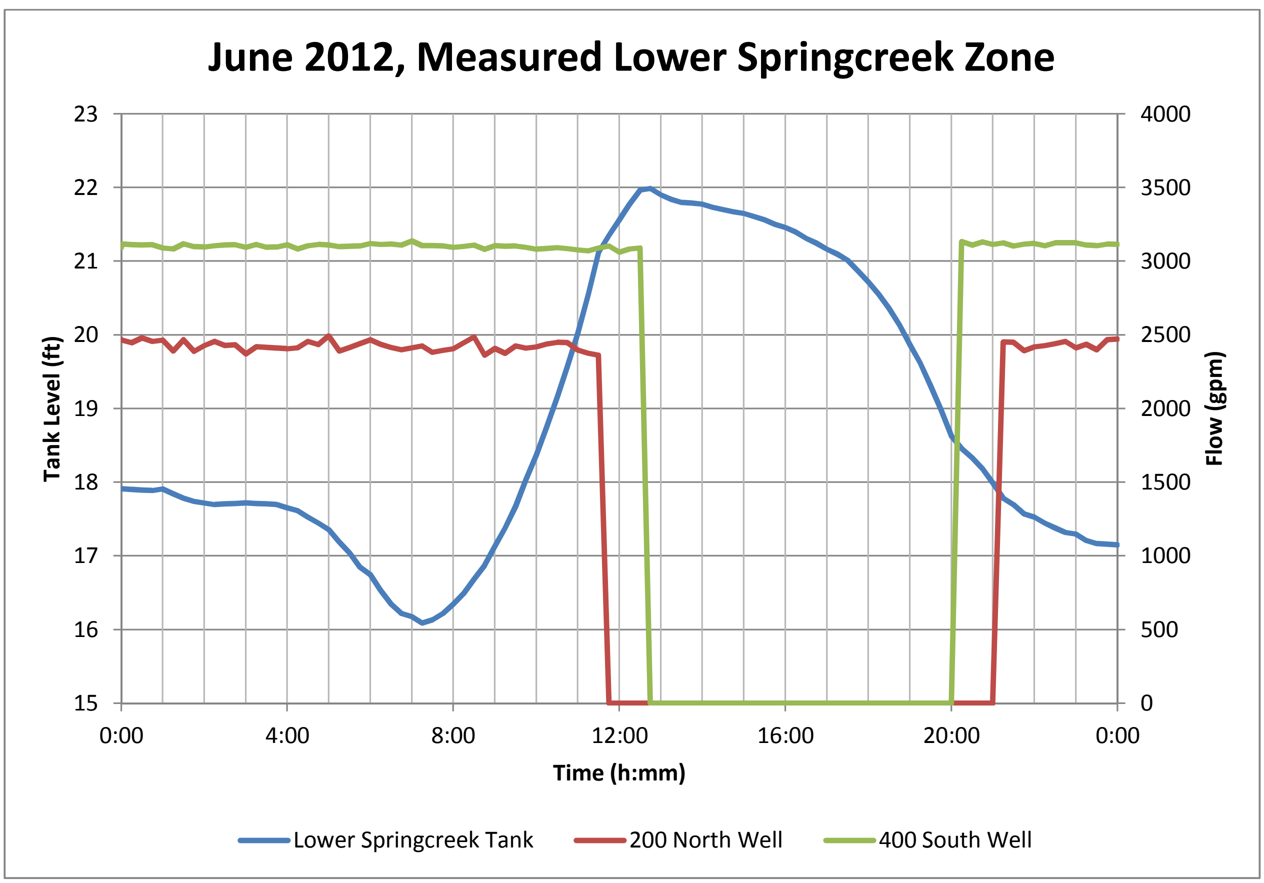
APPENDIX A

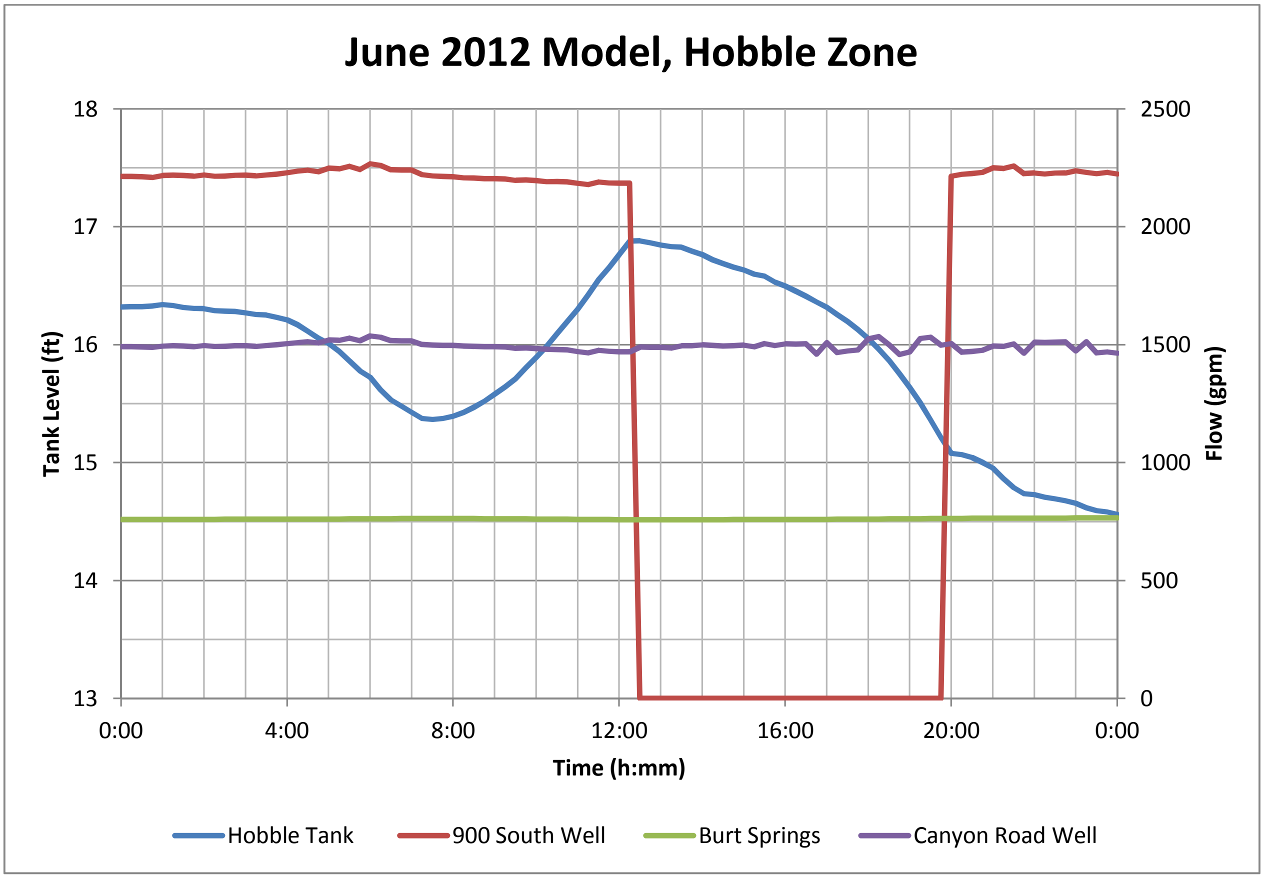
EPANET 2.0 FILES

APPENDIX B

CALIBRATION DATA


June 2012 Model, Lower Springcreek Zone
Tank Level (ft)
Flow (gpm)
Time (h:mm)
23
22
21
20
19
18
17
16
15
4000
3500
3000
2500
2000
1500
1000
500
0
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Lower Springcreek Tank
200 North Well
400 South Well


June 2012, Measured Lower Springcreek Zone
Tank Level (ft)
Flow (gpm)
Time (h:mm)
23
22
21
20
19
18
17
16
15
4000
3500
3000
2500
2000
1500
1000
500
0
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Lower Springcreek Tank
200 North Well
400 South Well


June 2012 Model, Hobble Zone
Tank Level (ft)
Flow (gpm)
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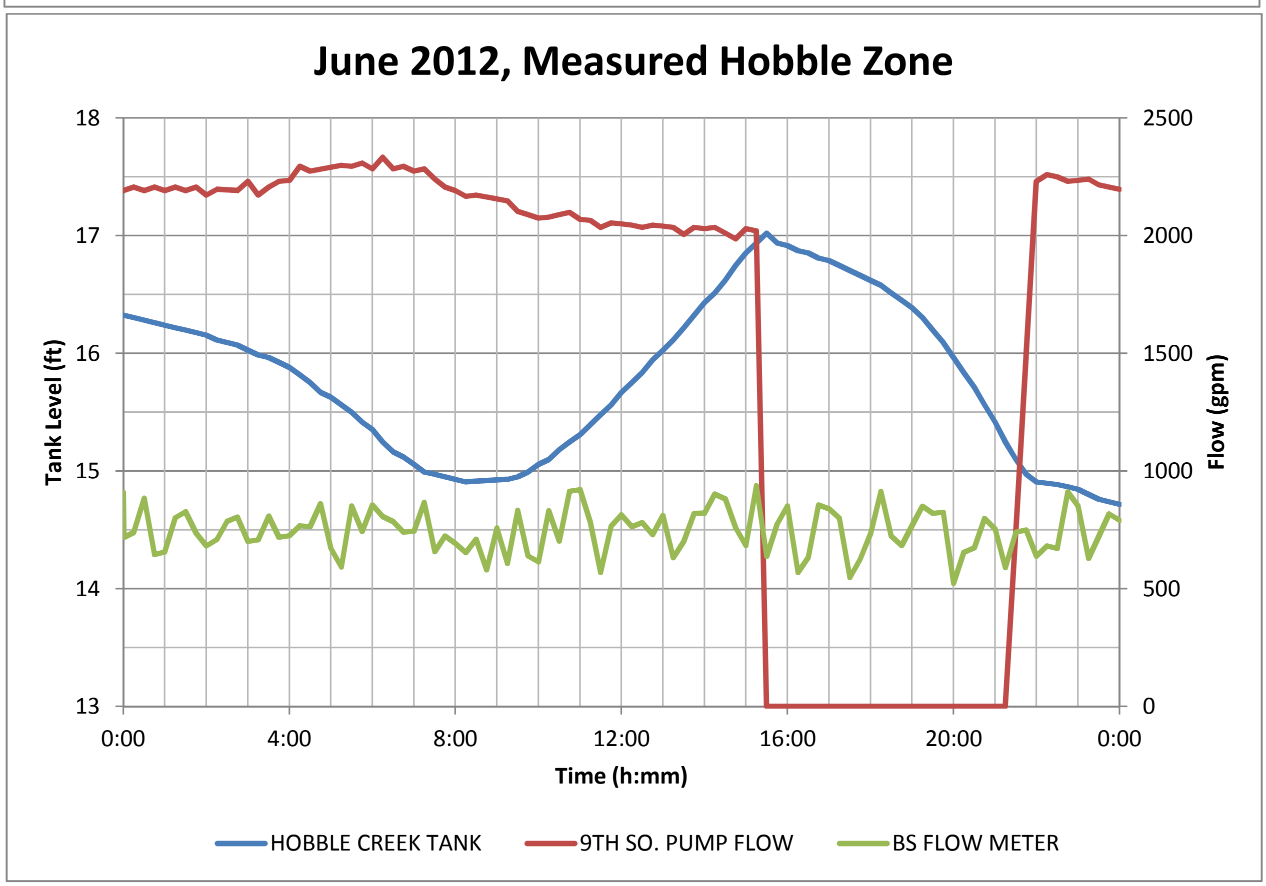
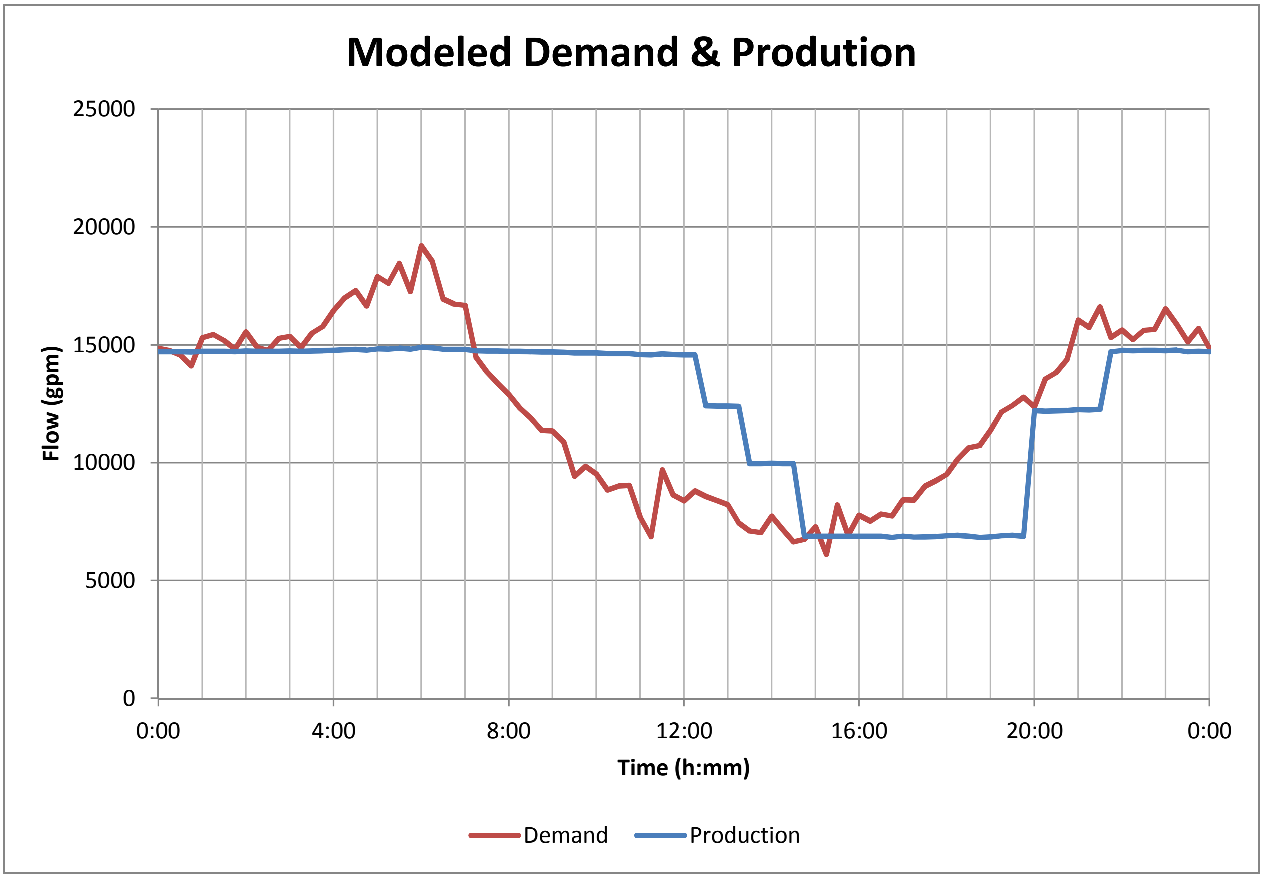
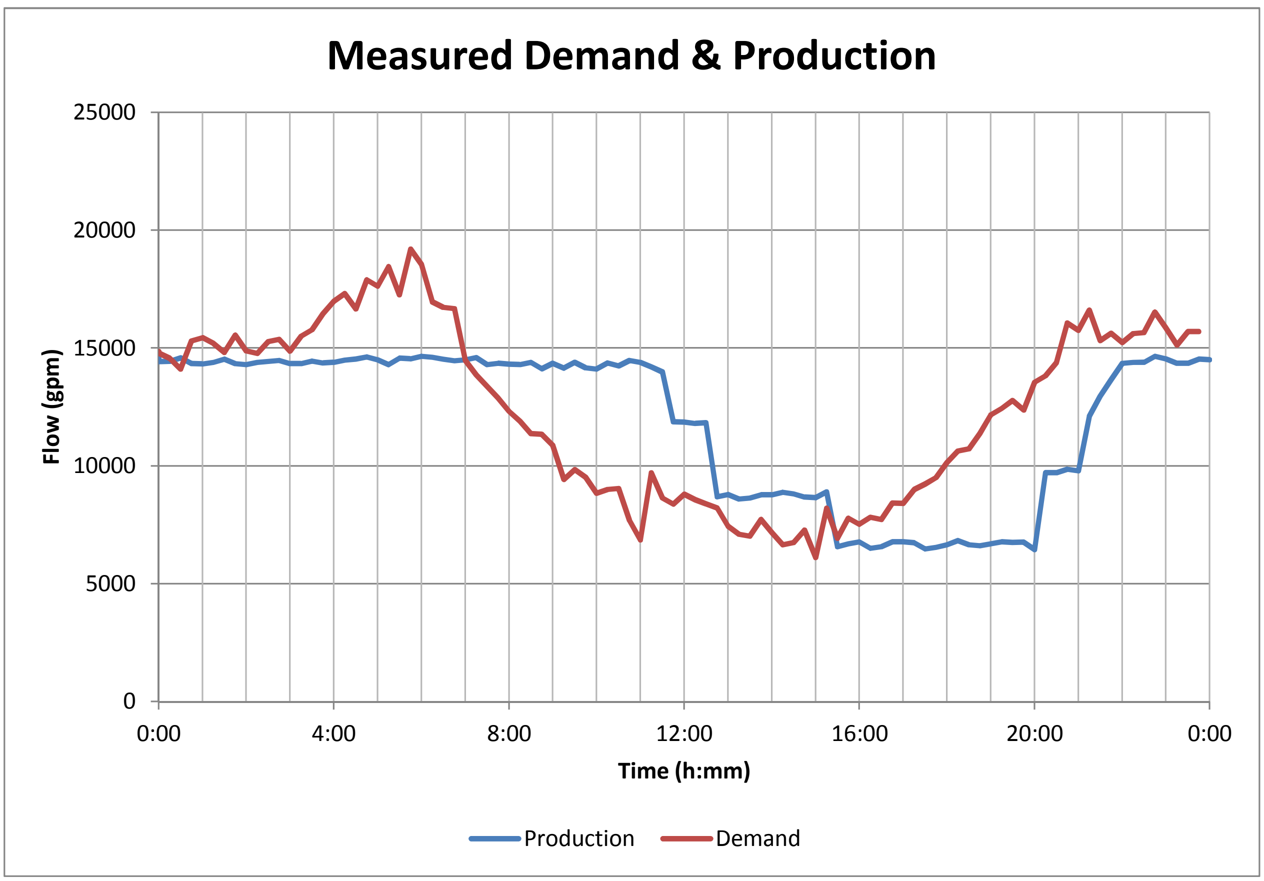
17
16
15
14
13
2500
2000
1500
1000
500
0
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time (h:mm)
Hobble Tank
900 South Well
Burt Springs
Canyon Road Well


June 2012, Measured Hobble Zone
Tank Level (ft)
Flow (gpm)
18
17
16
15
14
13
2500
2000
1500
1000
500
0
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time (h:mm)
HOBBLE CREEK TANK
9TH SO. PUMP FLOW
BS FLOW METER


Modeled Demand & Prodution
25000
20000
15000
10000
5000
0
Flow (gpm)
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time (h:mm)
Demand
Production


Measured Demand & Production
25000
20000
15000
10000
5000
0
Flow (gpm)
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time (h:mm)
Production
Demand

APPENDIX C

SYSTEM MASS BALANCE

SPRINGVILLE WATER OPTIMIZATION ANALYSIS - EXISTING SYSTEM (Average Day in June 2012)

PRESSURE ZONE				STORAGE	SOURCES				PUMP STATIONS						PRVs		DEMAND			ELECTRICITY COST	
Name	Upper Head (ft)	Lower Head (ft)	Pressure Fluctuation (psi)	Name	Name	Electricity Cost (per ac-ft)	Capacity (gpm)	Flow (gpm)	Name	Electricity Cost (per ac-ft)	Booster Model Flow gpm	Capacity (gpm)	Flow In (gpm)	Flow Out (gpm)	PRV Flow In (gpm)	PRV Flow Out (gpm)	Zone (gpm)	Total Supply (gpm)	Total Demand (gpm)	Peak Month (per ac-ft)	Peak Month Estimate
Bartholomew	6246	6236	5	Bartholomew	Bartholomew Springs	$0.00	2,700	2,700							NA	2,675	25	2700	2700	$0	$0
Upper Spring Creek	5134	5130	2	Upper Spring Creek	Spring Creek Springs	$0.00	2,700	1,200	Lower Spring Crk	$90	3,360	3,360	0	NA	NA	1,133	67	1,200	1,200	$0	$0
Rotary	5106	5105	3	Rotary					Lower Spring Crk	$90	3,360	3,360	0	NA	2,675	2,584	91	2,675	2,675	$0	$0
									Kelly's Grove	$135	47	Unknown	NA	91							
Kelly's Grove	5262	5282	1	Kelly's Grove					Kelly's Grove	$135	47	Unknown	91	NA	0	0	91	91	91	$135	$1,629
Rotary PRV Zone	4992	4989	3												530	0	530	530	530	$0	$0
Crandall	4987	4971	15												907	771	136	907	907	$0	$0
Klauck	4887	4883	1												238	0	238	238	238	$0	$0
Hobble Creek	4897	4868	23	Hobble Creek 1	900 S Well	$45.11	3,200	1,969							0	1,583	2,886	4,469	4,469	$54	$31,771
				Hobble Creek 2	1000 S Well	$72.02	550	350													
					Burt Springs (pumped)	$64.24	1,200	750													
					Canyon Road Well	$55.31	2,000	1,400													
					Evergreen Well	Not Used	600	0													
Lower Spring Creek	4835	4749	27	Lower Spring Creek 1	200 N	$55.82	3,200	1,500	Lower Spring Crk	$90	3,360	3,360	NA	0	3,863	3,379	4,484	7,863	7,863	$43	$22,895
				Lower Spring Creek 2	400 S	$38.68	3,000	2,300													
					Konold	$0.00	200	200													
Nestle	4765	4760	3												533	0	533	533	533	$0	$0
West Fields	4727	4713	6												3,379	NA	3,379	3,379	3,379	$0	$0
					TOTALS		**19,350**	**12,369**					**91**	**91**	**12,125**	**12,125**	**12,460**	**24,585**	**24,585**		**$56,295**

SPRINGVILLE WATER OPTIMIZATION ANALYSIS - PROPOSED SYSTEM (Average Day in June 2012)

PRESSURE ZONE				STORAGE	SOURCES				PUMP STATIONS						PRVs		DEMAND			ELECTRICITY COST	
Name	Upper Head (ft)	Lower Head (ft)	Pressure Fluctuation (psi)	Name	Name	Electricity Cost (per ac-ft)	Capacity (gpm)	Flow (gpm)	Name	Electricity Cost (per ac-ft)	Booster Model Flow gpm	Capacity (gpm)	Flow In (gpm)	Flow Out (gpm)	PRV Flow In (gpm)	PRV Flow Out (gpm)	Zone (gpm)	Total Supply (gpm)	Total Demand (gpm)	Peak Month (per ac-ft)	Peak Month Estimate
Bartholomew	6246	6236	5	Bartholomew	Bartholomew Springs	$0.00	2,700	2,700							NA	2,675	25	2700	2700	$0	$0
Upper Spring Creek	5134	5130	5	Upper Spring Creek	Spring Creek Springs	$0.00	2,700	1,200	Lower Spring Crk	$90	3,360	3,360	0	NA	NA	1,133	67	1,200	1,200	$0	$0
Rotary	5106	5105	2	Rotary					Lower Spring Crk	$90	3,360	3,360	0	NA	2,675	2,584	91	2,675	2,675	$0	$0
									Kelly's Grove	$30	47	Unknown	NA	91							
Kelly's Grove	5262	5282	1	Kelly's Grove					Kelly's Grove	$30	47	Unknown	0	NA	0	0	91	0	91	#DIV/0!	$0
Rotary PRV Zone	4992	4989	1												530	0	530	530	530	$0	$0
Crandall	4987	4971	10												374	238	136	374	374	$0	$0
Klauck	4887	4883	4												238	0	238	238	238	$0	$0
Hobble Creek	4897	4868	8	Hobble Creek 1	1000 S Well	$53.00	550	160							2,054	437	2,886	3,414	3,323	$24	$4,306
				Hobble Creek 2	Burt Springs (pumped)	$20.00	1,200	1,200													
					Canyon Road Well	$55.31	2,000	0													
					Evergreen Well	Not Used	600	0													
Lower Spring Creek	4835	4749	14	Lower Spring Creek 1	900 S Well	$29.00	3,200	2,550	Lower Spring Crk	$90	3,360	3,360	NA	0	1,196	3,912	4,484	8,396	8,396	$37	$35,119
				Lower Spring Creek 2	200 N	$51.00	3,200	1,450													
					400 S	$39.00	3,000	3,000													
					Konold	$0.00	200	200													
Nestle	4765	4760	5												533	0	533	533	533	$0	$0
West Fields	4727	4713	6												3,379	NA	3,379	3,379	3,379	$0	$0
					TOTALS		**19,350**	**12,460**					**0**	**91**	**10,979**	**10,979**	**12,460**	**23,439**	**23,439**		**$39,425**

APPENDIX D

WATER QUALITY DATA

Chlorine Calibration Data
Sampling period: 6/5/2012 to 6/20/2012
Number in parenthesis denotes the number of field samples during the sampling period

Chlorine Concentration (mg/L)

	Test Range		Model Range	
Location	Low	High	Low	High
Shop (5)	0.0	0.1	0.00	0.56
Golf Course (2)	1.1	1.1	1.00	1.00
Hydro (2)	0.1	0.3	1.00	1.00
HC Valve House (6)	0.1	1.0	0.01	0.60
City Center (6)	0.0	0.1	0.01	0.54
T-Bone Café (3)	0.1	0.1	0.01	0.30
1455 N 1750 W (3)	0.0	0.1	0.03	0.33
551 Walnut Glen (1)	0.3	0.3	0.01	0.40
PC School (1)	0.0	0.0	0.03	0.34
427 E 1050 N (1)	0.6	0.6	0.60	0.60
Evco (1)	0.2	0.2	0.00	0.40

Chlorine varies temporally and spatially within the drinking water network. Most sites had multiple samples collected at the test location. For test sites where multiple samples were collected, the measured range of concentration is given. Similarly, the highest and lowest modeled concentrations are also presented. Chlorine concentrations vary greatly even within the space of a day. The sites with the most sampling had 6 sample collected over a roughly two week period. Even such relatively frequent sampling does not guarantee that high and low chlorine concentrations will be captured by the sampling regimen. For that reason, it is expected that the tested concentrations will broadly reflect the modeled concentrations, but that more exact comparisons cannot be made.